HESS OIL VIRGIN ISLANDS CORP.

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1501 McKinney Street Houston, Texas 77010

August 22, 2022

Mr. Adolph Everett, Chief Hazardous Waste Programs Branch US Environmental Protection Agency, Region 2 290 Broadway New York, New York 10007-1866

Re: St. Croix Alumina Site Administrative Order Docket No. RCRA-0202001-7301 Phase 2 Natural Source Zone Depletion Assessment Report EPA Facility ID No. VID090302084

Dear Mr. Everett:

The Project Operating Committee (POC) is pleased to provide the enclosed *Phase 2 Natural Source Zone Depletion Assessment Report* for the St. Croix Alumina Site, St. Croix, U.S. Virgin Islands (hereafter 'Site') to the United States Environmental Protection Agency (USEPA). The primary objective of the Phase 2 Natural Source Zone Depletion (NSZD) study was to utilize advanced methods to quantify mass depletion rates. A dynamic closed chamber (DCC) study using a LI-COR meter was selected as the optimal means for acquiring high-resolution NSZD rate data as it allowed for the densest sampling grid. To provide additional lines of evidence, the following were also completed:

- Four clusters of multilevel soil vapor sampling wells (SG-1 through SG-4) were installed to assess NSZD rates using the gas gradient method.
- Temperature measurements were taken at multiple depths in monitoring wells to quantify NSZD rates using the temperature gradient method.
- Monitoring well headspace readings were taken as a qualitative verification of the DCC results.

The information discussed in this Phase 2 NSZD Assessment report demonstrates that NSZD rates exceed mass removal through active LNAPL recovery. As such, the POC recommends terminating active LNAPL recovery at wells VW5, VW20, VW20B, VW21B, VW23, VW24, VW29, VW30, and VW32. Further, the POC recommends continued active LNAPL recovery at wells VW2, VW6, VW13, VW13B, VW14, and VW31.

Upon EPA's approval, the POC will cease active recovery in the above-mentioned wells. Feel free to contact me if you have any questions or comments.

Sincerely,

Brian Epperson Remediation Manager

Cc: Mr. Ricardito Vargas (Electronic Copy)

Project Manager

Land and Redevelopment Programs Branch, Land, Chemicals and Redevelopment Division

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Phase 2 Natural Source Zone Depletion Assessment Report St. Croix, U.S. Virgin Islands

Prepared for:

St. Croix Alumina Site

Prepared by:

EHS Support

August 2022



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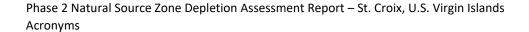
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Acronyms

°C degrees Centigrade

% vol not measured

AOC Administrative Order on Consent

CSM Conceptual Site Model
DCC dynamic closed chamber

DPPHC dissolved phase petroleum hydrocarbon constituents

ft feet

HOVIC Hess Oil Virgin Islands Corporation

ITRC Interstate Technology & Regulatory Council

LNAPL light non-aqueous phase liquid MNA monitored natural attenuation

nm not measured

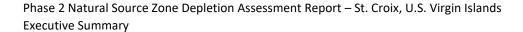
NSZD natural source zone depletion POC Project Operating Committee

PSPH phase separated petroleum hydrocarbons

USEPA United States Environmental Protection Agency

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EHS Support LLC iii





Executive Summary

Monitoring and recovery well temperature and headspace gas data confirm active, robust natural source zone depletion (NSZD) is occurring at the St. Croix Alumina facility in St. Croix, U.S. Virgin Islands ("Site"). Active NSZD has been confirmed through the July 2021 Phase 1 NSZD study (EHS Support, 2021b) and the April 2022 Phase 2 NSZD study described herein. Based on both studies, sulfate reduction and methanogenesis are the primary light non aqueous phase liquid hydrocarbon (LNAPL) degradation mechanisms as confirmed by elevated concentrations of methane and hydrogen sulfide measured in the headspace of monitoring wells.

NSZD rate estimates based on the temperature gradient NSZD method completed for the Phase 1 and Phase 2 NSZD studies were a similar order of magnitude, indicating mass depletion rates are stable over time. However, NSZD rates calculated using these methods are biased low at the Site and rate estimates using a Licor meter are preferred as they provide higher spatial resolution and lower cost than alternative high-resolution methods.

The Phase 2 NSZD study included measuring methane and carbon dioxide flux with a Licor meter at ground surface over a dense grid of locations across the Site. Areas of highest methane and carbon dioxide flux measured at the ground surface with the Licor meter corresponded with the current extent of LNAPL that is greater than 0.2 feet thick, indicating the methane and carbon dioxide flux is associated with processes coinciding with the LNAPL plume. Replicate DCC measurements at the same locations on different days and at different times showed only small variations in gas flux. These results indicate mass depletion rates are stable with time.

Mass losses determined using high-resolution DCC measurements range between 24,928 gallons and 47,928 gallons per year. These values are consistent with NSZD rates for LNAPL-affected sites elsewhere that are reported in peer-reviewed publications. NSZD rates currently exceed LNAPL recovery rates (3,167 gallons of LNAPL recovered in the last 12 months through May 31, 2022). The re-analysis of the recovery data indicates that most wells have met the triggers contained in the decision logic diagrams. New statistical methods have improved the fit and aided in demonstrating we have met the 90 percent recovery threshold in five wells, and three wells are close to approaching the 90 percent threshold.

Preliminary assessment (as noted above) demonstrates that NSZD rates exceed mass removal through active LNAPL recovery. Active recovery is providing limited benefits and termination of active LNAPL recovery operations is recommended at wells VW5, VW20, VW20B, VW21B, VW23, VW24, VW29, VW30, VW32 (as documented in Table 2-1 of **Appendix B**) given that the Phase 2 NSZD results confirm that NSZD losses are much greater than what can be currently recovered.



1 Introduction

The following companies entered into an Administrative Order on Consent (AOC), with the United States Environmental Protection Agency (USEPA), Region 2, on May 14, 2001, with an effective date of May 24, 2001:

- St. Croix Alumina, LLC
- ALCOA World Alumina, LLC (formerly known as ALCOA Alumina and Chemical, LLC)
- Virgin Islands Alumina Company
- Century Aluminum Company, Inc.
- Lockheed Martin Corporation
- Hess Oil Virgin Islands Corporation (HOVIC)
- HOVENSA LLC

Pursuant to the AOC, these companies have agreed to work together to address the phase separated petroleum hydrocarbons (PSPH) and dissolved phase petroleum hydrocarbon constituents (DPPHC) located beneath the Site (**Figure 1**). Per the AOC, a Project Operating Committee (POC) was formed to design, install, and operate a monitoring and remediation system for the Site.

A Draft PSPH Work Plan was submitted to the USEPA on July 23, 2001 (HOVIC, 2001a). USEPA approved the PSPH Work Plan on August 8, 2001. Implementation of the PSPH Work Plan has been initiated and both PSPH and DPPHC recovery is underway. The initial Draft DPPHC Work Plan was submitted to USEPA on September 21, 2001 (HOVIC, 2001b). The USEPA requested seven items be incorporated into a revised draft. This revised Draft DPPHC Work Plan was submitted to the USEPA on December 21, 2001 (HOVIC, 2001c). USEPA conditionally approved the work plan in a letter dated January 15, 2002, with proposed changes to timeline items (USEPA, 2002). An amended Draft DPPHC Work Plan was submitted to the USEPA on February 22, 2002, incorporating the requested USEPA timeline changes (HOVIC, 2002). The POC recommended that the quarterly status reports and the semiannual report be consolidated into one report to be submitted semiannually. The USEPA approved this recommendation in their letter on March 3, 2005.

The POC submitted a Draft PSPH Pilot Study and DPPHC Sampling Plan Modification to USEPA on May 21, 2018 (HOVIC, 2018a). USEPA provided comments to the proposed plan, which were implemented by the POC, and a Final PSPH Pilot Study and DPPHC Sampling Plan Modification was submitted on June 11, 2018 (HOVIC, 2018b). This recovery plan was implemented by the POC over 2018, 2019, and the first quarter of 2020.

Using historical data and the data collected from this modified LNAPL recovery program, a detailed assessment of LNAPL recovery/mobility and chemistry data was completed and reported in the July 2020 LNAPL Conceptual Site Model (CSM) and Remedial Action Work Plan (EHS Support, 2020). This assessment demonstrated that the majority of LNAPL recovery wells have reached or are approaching a practicality endpoint. In addition, the CSM and Remedial Action Work Plan proposed shutdown criteria for active recovery wells (EHS Support, 2020). However, the report recommended that due to uncertainties and data gaps, recovery operations, including well maintenance and semiannual groundwater monitoring should continue.

Phase 2 Natural Source Zone Depletion Assessment Report – St. Croix, U.S. Virgin Islands Introduction



As a supplement to the continued routine groundwater sampling activities and the extension of the program of LNAPL recovery activities, EHS Support (2021a) proposed that additional analysis be conducted to support the assessment of NSZD processes in the aquifer. Based on the Site geohydrology and limited geochemical data, a combination of sulfate reduction and methanogenesis processes appear to be active and significant contributors to mass losses at the Site. A program of works was proposed to further define and quantify the processes contributing to natural mass losses.

As such, EHS Support developed and submitted an NSZD Work Plan ("Work Plan") to USEPA in April 2021 (EHS Support, 2021a). The objective of the Work Plan was to provide the protocols and procedures for a geohydrology and geochemistry assessment to facilitate a better understanding of, and to quantify the natural attenuation degradation of, the historical dissolved and phase-separated impacts in groundwater at the Site. EHS Support proposed an iterative process consisting of two phases that use a combination of existing monitoring well geochemistry data and soil gas flux analysis in accordance with established NSZD and monitored natural attenuation (MNA) technical guidance (Interstate Technology & Regulatory Council [ITRC], 2009; CRC CARE, 2015 and 2018).

The objective of the Phase 1 NSZD Study was to develop a better understanding of and to provide a preliminary quantification of natural attenuation and degradation of the historical DPPHC and PSPH impacts in groundwater at the Site to inform the approach for the Phase 2 works. Results of the Phase 1 NSZD Study were submitted to USEPA in a report dated September 30, 2021 (EHS Support, 2021b). USEPA provided comments on the Phase 1 NSZD Study Report in a letter dated November 1, 2021. A response to the USEPA comments was provided in a letter dated December 7, 2021. USEPA accepted the response to comments in a letter dated January 28, 2022, which also contained additional comments and a request for clarification. The January 28, 2022 letter confirmed key agreements were acceptable, including the provision that comments from USEPA and their contractor on the Phase 1 NSZD Study Report would be incorporated into the Phase 2 NSZD Study Report.

The objective of this Phase 2 NSZD Study was to use of advanced methods to quantify mass depletion rates. A dynamic closed chamber (DCC) study using a LI-COR meter was selected as the optimal means for acquiring high-resolution NSZD rate data as it allowed for the densest sampling grid. Unlike other alternatives, the use of a LI-COR meter also provided the flexibility to assess if methane is fully degraded in the subsurface. To provide additional lines of evidence, the following were completed:

- Four clusters of multilevel soil vapor sampling wells (SG-1 through SG-4) were installed to assess NSZD rates using the gas gradient method.
- Temperature measurements were taken at multiple depths in monitoring wells to quantify NSZD rates using the temperature gradient method.
- Monitoring well headspace readings were taken as a qualitative verification of the DCC results.

1.1 Summary of Phase 1 NSZD Study Results

The findings and recommendations of the Phase 1 NSZD Study were as follows:

- 1. The temperature and soil gas data showed active, robust NSZD is occurring at the Site.
- 2. Preliminary estimates of mass losses using temperature data were between 7,175 gallons and 8,275 gallons per year. These NSZD rates currently exceed annual LNAPL recovery rates (3,384 gallons of LNAPL recovered in the last 12 months (as of the Phase 1 NSZD Study submittal date).

Phase 2 Natural Source Zone Depletion Assessment Report – St. Croix, U.S. Virgin Islands Introduction



- 3. The high methane detections and large aerial extent of the facility warrant the use of a LI-COR meter equipped with a methane sensor rather than a passive E-Flux carbon dioxide trap to quantify mass loss more accurately in the unsaturated zone.
- 4. A LI-COR meter will facilitate a higher-density sampling grid at limited additional cost.
- 5. The re-analysis of the recovery data indicates that most wells have met the triggers contained in the decision logic diagrams. New statistical methods have improved the fit and aided in demonstrating we have met the 90 percent recovery threshold in five wells and two wells are close to approaching the 90 percent threshold.
- 6. Preliminary assessment (as noted above) demonstrates that NSZD rates exceed mass removal through active LNAPL recovery. Termination of active LNAPL recovery operations is likely given the expected Phase 2 NSZD results that confirm the NSZD losses are much greater than what can be currently recovered.

1.2 NSZD Study Decision Logic Process

The goals of the Phase 2 NSZD Study were designed to confirm the degree to which NSZD depletion is active at the Site using higher-resolution sampling methods than were implemented during the qualitative Phase 1 NSZD Study. The following multiple lines of evidence were evaluated to establish evidence for active NSZD during the Phase 2 NSZD Study:

- 1. Qualitatively confirm NSZD processes are occurring at the Site through observation of elevated temperature and biogenic gases in source area wells (elevated carbon dioxide, methane, and/or hydrogen sulfide; depleted oxygen).
- 2. Calculate high-resolution NSZD rates using the DCC method.
- 3. Support calculated DCC NSZD rates using gas gradient measurements from multi-level soil vapor probes and multi-level temperature measurements in monitoring wells.

A decision flowchart for interpreting the data collected during the Phase 2 NSZD Study is provided in **Figure 1-1**.



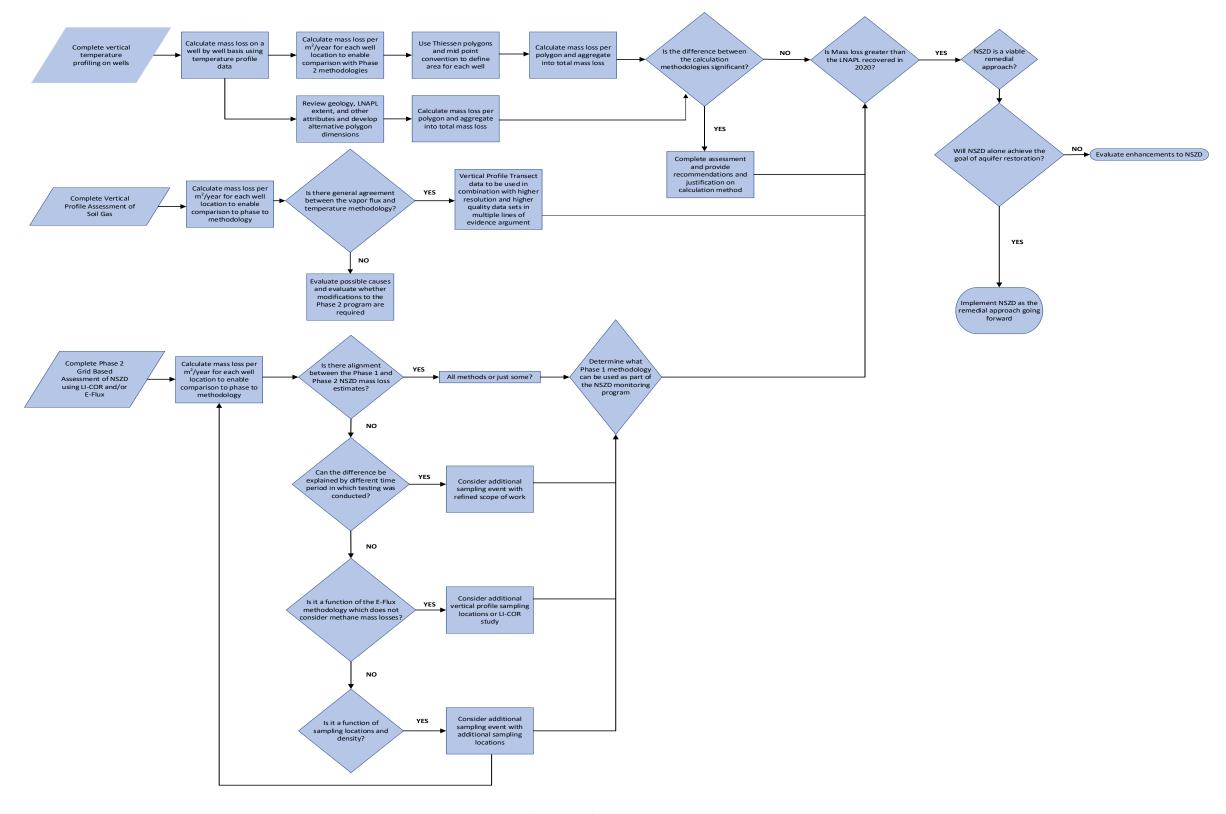


Figure 1-1 Decision flowchart for interpreting Phase 2 NSZD Study results.

Phase 2 Natural Source Zone Depletion Assessment Report – St. Croix, U.S. Virgin Islands Introduction



1.3 Phase 2 NSZD Report Structure

To facilitate review of this Phase 2 NSZD Report, the document has been structured to provide key findings and conclusions in the main body of the report. Details of how comments on the Phase 1 NSZD Report were incorporated into this study, along with all data, calculations, assumptions, and conclusions pertaining to the Phase 2 NSZD Study are provided in **Appendix A**. Data, methods, and conclusions pertaining to a revised LNAPL mobility/recoverability assessment are provided in **Appendix B**.



2 Phase 2 Tasks

The Phase 2 work consisted of the following field tasks:

- **Temperature Profiling** A downhole temperature profiling assessment was completed in the unsaturated and saturated zones to determine the temperature gradient at the selected wells.
 - Five unsaturated zone temperature readings were measured at each well (2 feet [ft] below ground surface, 1 ft above groundwater, and three intervals equally spaced in between).
 - Three saturated zone temperature readings were completed at each well (1 ft below the groundwater interface, 5 ft below the groundwater surface, and 10 ft below the groundwater surface).
- Well Headspace Gas Deep vadose methane, carbon dioxide, and hydrogen sulfide gas
 concentrations were measured 1 foot above the water table in all wells where temperature
 profiles were completed following the technique of Sweeney and Ririe (2017). Oxygen was also
 measured in wells adjacent to newly installed multi-level soil gas monitoring points.
- Multi-level Soil Vapor Soil Gas Four clusters of multi-level soil gas monitoring points (SG-1 through SG-4) were installed adjacent to existing monitoring wells MMX, VW20, VW31, and VW13, respectively (Figure 2). The locations adjacent to wells afforded the ability to collect a deep soil gas measurement immediately above the liquid level in the well and minimize the possibility of groundwater periodically flooding the deep vapor point in each cluster. The generalized construction of each soil vapor point cluster consisted of four sampling points installed in adjacent borings at the following depths:
 - 5 feet above the groundwater table (targeting the sand unit present at or above most screened intervals)
 - o ¼ distance between the ground surface and the top of the well screen
 - o ¾ distance between the ground surface and the top of the well screen
 - 5 feet below ground surface

Methane, carbon dioxide, hydrogen sulfide, and oxygen were measured at each sampling point on May 3, 2022, and May 5, 2022.

 DCC measurements using a LI-COR meter – Ground surface methane and carbon dioxide flux were measured at 57 locations. Locations were selected to represent a range of ground surface cover types. Measurements were made at different times and on different days at several locations to verify temporal gas flux stability.

All results and detailed descriptions of field sampling and data assessment methods are provided in **Appendix A**.



3 Phase 2 Qualitative NSZD Results

The Phase 1 NSZD Study Report (EHS Support, 2021b) was designed to qualitatively confirm the degree to which NSZD depletion is active at the Site. Multiple lines of evidence provided in the Phase 1 NSZD Study Report support the occurrence of robust NSZD processes at the Site with groundwater geochemistry and electron acceptors indicating that sulfate reduction and methanogenesis are the dominant mass loss mechanisms.

To provide a point of comparison with the Phase 1 NSZD Study and to demonstrate the long-term stability of NSZD processes, the following multiple lines of qualitative evidence for active NSZD processes were evaluated during the Phase 2 NSZD Study:

- 1. Elevated temperature in the vadose zone (i.e., 1 foot above groundwater) is an indicator of volatile phase exothermic NSZD reactions.
- 2. Elevated temperature in the saturated zone (i.e., 1 foot below groundwater) is an indicator of aqueous and volatile phase exothermic NSZD reactions.
- 3. Biogenic gases were identified in source area wells (elevated methane, carbon dioxide, and hydrogen sulfide).

Data, results, and a detailed discussion of the Phase 2 qualitative NSZD assessment are provided in **Appendix A**.

The following is a summary of qualitative NSZD results from the Phase 2 NSZD Study:

- Elevated unsaturated and saturated zone temperatures in the source area, compared to background locations, qualitatively indicate robust LNAPL degradation is occurring.
- Well headspace measurements of carbon dioxide, methane, and hydrogen sulfide are elevated in source area wells compared to background wells, confirming active NSZD is occurring.
- Qualitative NSZD indicators persisted between the Phase 1 NSZD Study and the Phase 2 NSZD Study, indicating that NSZD processes are temporally stable and are persistent.

A comparison of qualitative NSZD results between the Phase 1 and Phase 2 Studies is summarized in **Table 3-1**. The comparison indicates similar ranges in background and source area temperatures and gas concentrations between the Phase 1 and Phase 2 NSZD Study sampling events, and demonstrates temporal stability of NSZD processes.

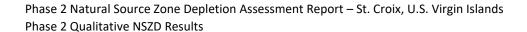




Table 3-1 Comparison of Phase 1 and Phase 2 Qualitative NSZD Results

Qualitative Method	Phase 1 NSZD Study	Phase 2 NSZD Study		
Unsaturated Zone				
Well Temperature (Range of Background) (°C)	27.3 to 28.0	28.2 to 28.9		
Well Temperature (Range of Source Area) (°C)	28.5 to 31.4	27.7 to 31.2		
Background Carbon Dioxide (% vol)	0 to 11.0	0.3 to 10.8		
Background Methane (% vol)	0 to 1.0	0 to 1.0		
Background Hydrogen Sulfide (% vol)	0 to 0	0 to 0		
Source Carbon Dioxide (% vol)	1.7 to 16.1	0.4 to 20.3		
Source Methane (% vol)	0 to 65.0	0 to 63.0		
Source Hydrogen Sulfide (% vol)	0 to >100	0 to >100		
Saturated Zone				
Well Temperature (Range of Background) (°C)	27.7 to 28.9	27.2 to 27.9		
Well Temperature (Range of Source Area) (°C)	28.4 to 31.3	28.5 to 31.3		

Well unsaturated zone temperatures and gas concentrations from 1 foot above groundwater.

Well saturated zone temperatures from 1 foot below groundwater.

[°]C = degrees Centigrade

[%] vol = percent by volume

NSZD = natural source zone depletion



4 Phase 2 Quantitative NSZD Results

The following quantitative calculations of NSZD depletion rates were completed as part of the Phase 2 NSZD Study:

- 1. Unsaturated zone NSZD rate was estimated using vadose and groundwater temperature data.
- 2. Unsaturated zone NSZD rate was estimated using multi-level vadose samples of carbon dioxide, methane, and oxygen concentrations.
- 3. Unsaturated zone NSZD rate was estimated using direct measurements of carbon dioxide and methane flux at ground surface using DCC methods.

The aqueous NSZD rate was calculated and provided in the Phase 1 NSZD Report. Detailed results and calculations of the quantitative NSZD assessment for the Phase 2 NSZD Study are provided in **Appendix A**.

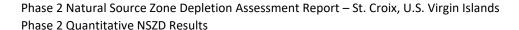
As shown on **Figure 3** and **Figure 4**, locations of elevated methane and carbon dioxide flux measured a DCC at ground surface closely match where LNAPL is present in the subsurface. Quantitative NSZD rate calculations confirm the qualitative evidence that active, robust NSZD is occurring at the Site.

Data provided in **Appendix B** show that LNAPL recovery at the Site from 2016 through 2021 (normalized to an annual rate) was 1,983.6 gallons/year. Total unsaturated zone NSZD rates based on high-resolution DCC measurements range from 24,834 to 47,928 gallons per year across the LNAPL affected area at the Site. The rate is likely slightly higher if aqueous-phase NSZD processes are considered, which were demonstrated to be active at the Site during the Phase 1 NSZD Study. The basis for areas used in the DCC rate calculations, and a comparison of natural versus engineered LNAPL mass losses are provided on **Figure 5** and **Figure 6**, respectively.

The NSZD rates based on DCC measurements are higher than estimated using temperature gradient and gas gradient methods (**Table 4-1**). The discrepancy is attributed to the following:

- Temperature and gas gradient approaches are highly sensitive to the height difference between sequential vertical measurements. A shorter vertical distance between measurements results in higher estimated NSZD rates. Given the large vertical spacing between temperature and gas gradient measurements, the results provide a minimum rate estimate as zones of peak or lowest temperature/ gas concentration may have fallen between sampled intervals.
- Horizontal spatial resolution is lower (sparse) compared to DCC measurements. This leads to a
 disproportionately large influence of non-detect/background Thiessen polygons on the overall
 calculated NSZD rate.
- Temperature and gas gradient methods rely on the use of non-Site-specific data and parameters, however, the DCC method does not.

Furthermore, it is critical to consider the calculation methods employed only consider mass transfers in the vertical domain. Vapor and energy (temperature) fluxes also occur horizontally and therefore the methods employed will underestimate mass losses. The higher density of DCC sampling relative to the well-based sampling for temperature and soil gases is likely to better capture both the vertical and lateral fluxes, and this may also account for the differences observed between methods.





NSZD rates calculated from DCC measurements were compared to literature values (all normalized to gallons/acre/year to provide valid comparison) to verify the magnitude of the DCC results is realistic (**Table 4-2**). The DCC results are within the range, but at the low end, of the NSZD rates reported for a diverse range of hydrocarbon sites. Lower rates likely reflect a combination of the chemistry of the LNAPL (middle distillates), its age and weathered state, and the dominant process (methanogenesis) which produces the least energy and therefore is slower relative to other natural degradation processes. This result indicates the DCC results are valid, and further indicates the temperature and gas gradient results are conservative estimates of NSZD rates that are potentially biased low.

The results of the Phase 2 NSZD Study identify that DCC is the preferred method to quantify NSZD rates at the Site, as alternate methods are susceptible to bias from low sampling densities and other factors. Given the high cost of alternative high-resolution NSZD quantification methods, comparable sampling grid densities as were achieved with the DCC method cannot be achieved due to prohibitive expense and would likely result in biased NSZD rate estimates. Additionally, the consistent tropical climate and results provided herein demonstrate that NSZD processes are temporally stable.



Table 4-1 Summary of NSZD Rates

Rate	NSZD Rate Attributed to Aqueous (Assimilative Capacity) Reactions	Unsaturated Zone NSZD Rate Based on Sum of Temperature Methods ¹ Gallo	Unsaturated Zone NSZD Rate Based on Gas Gradient Method ² ns per year	NSZD Rate Attributed to Unsaturated Zone (DCC Method) ³	
		Phase 1 NSZD Study			
Upper-End NSZD Rate	703	8,276		nm	
Mean NSZD Rate	508	7,820	nm	nm	
Lower-End NSZD Rate	310	7,175		nm	
	Phase 2 NSZD Study				
Upper-End NSZD Rate	nm	12,747		47,928	
Mean NSZD Rate	nm	12,428	8,049 to 9,057*	36,910	
Lower-End NSZD Rate	nm	12,003		24,834	

¹Sum of differential temperature and groundwater temperature methods.

DCC = dynamic closed chamber

nm = not measured

NSZD = natural source zone depletion

Table 4-2 NSZD Rates at Site Compared to Literature Values

Site Type	Number of Sites	Site-Wide NSZD Rate (Gallons/Acre/Year)
Fuel/diesel/gasoline sites	5	300 to 3,100 ¹
Diverse petroleum sites	11	300 to 5,600 ¹
All studies	25	300 to 700 ¹
St. Croix Alumina DCC maximum	1	564 ²
St. Croix Alumina DCC average	1	434 ²
St. Croix Alumina DCC minimum	1	292 ²

¹ Values sourced from Garg et al. (2017).

DCC = dynamic closed chamber

LNAPL = light non-aqueous phase liquid

NSZD = natural source zone depletion

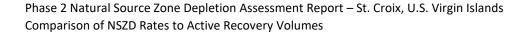
Garg, S., C.J. Newell, P.R. Kularni, D.C. King, D.T. Adamson, M.I. Renno, and T. Sale. (2017). Overview of Natural Source Zone Depletion: Processes, Controlling Factors, and Composition Change. Groundwater Monitoring & Remediation 37(3), 2017.

² Gas gradient method.

³ Total unsaturated zone NSZD rate for Phase 1 Study is the sum of the groundwater temperature gradient methods. For the Phase 2 Study, this value is the high-resolution DCC measurement.

^{* = 12,074} to 14,261 gallons per year if SG-3 data is considered to be unrepresentative.

 $^{^{\}rm 2}$ Site values are calculated assuming the LNAPL affected area is 85 acres.





5 Comparison of NSZD Rates to Active Recovery Volumes

To facilitate comparison between NSZD rates and active recovery volumes, an update was made to the LNAPL recovery/mobility assessment that was completed and reported in the July 2020 LNAPL Conceptual Site Model (CSM) and Remedial Action Work Plan (EHS Support, 2020). The update included additional recovery data acquired up until May 2022, and the results are provided in **Appendix B**.

The re-analysis of the recovery data indicates that most wells have met the triggers contained in the decision logic diagrams. New statistical methods have improved the fit and aided in demonstrating we have met the 90 percent recovery threshold in five wells, and three wells (VW24, VW21B, and VW29) are close to approaching the 90 percent threshold.

Further, a number of other wells exhibit very low LNAPL recovery rates and associated LNAPL transmissivities. Reservoir decline curve analysis is not a practical analysis tool on these data sets. Continued operation of these recovery wells provides limited benefits and NSZD rates are orders of magnitude higher than the LNAPL volumes that can be recovered.

As indicated on **Figure 6**, Phase 2 NSZD Study results confirm that LNAPL NSZD losses across the site exceed what can currently be recovered.



6 Findings and Recommendations

Findings and recommendations of this Phase 2 report include:

- 1. The temperature and soil gas data confirm active, robust NSZD is occurring at the Site. However, NSZD rates calculated using these methods are biased low at the Site.
- 2. Methane and hydrogen sulfide gas detections in monitoring wells confirm that LNAPL degradation is occurring via sulfate reduction and methanogenesis.
- 3. Areas of highest methane and carbon dioxide flux measured at the ground surface using the DCC method correspond with the current extent of LNAPL that is greater than 0.2 feet thick.
- 4. Replicate DCC measurements at the same locations on different days and at different times showed only small variations in gas flux. Mass depletion rates calculated using the temperature gradient and groundwater temperature methods during the Phase 1 and Phase 2 NSZD studies were a similar order of magnitude. These results indicate mass depletion rates are stable with time.
- 5. Mass losses determined using high-resolution DCC measurements range between 24,928 gallons and 47,928 gallons per year. These values are consistent with NSZD rates for LNAPL-affected sites elsewhere that are reported in peer-reviewed publications. NSZD rates currently exceed LNAPL recovery rates (3,167 gallons of LNAPL recovered in the last 12 months through May 31, 2022).
- 6. The re-analysis of the recovery data indicates that most wells have met the triggers contained in the decision logic diagrams. New statistical methods have improved the fit and aided in demonstrating we have met the 90 percent recovery threshold in five wells and three wells (VW24, VW21B, and VW29) are close to approaching the 90 percent threshold.
- 7. Preliminary assessment (as noted above) demonstrates that NSZD rates exceed mass removal through active LNAPL recovery. Active recovery is providing limited benefits and termination of active LNAPL recovery operations is recommended at wells VW5, VW20, VW20B, VW21B, VW23, VW24, VW29, VW30, VW32 (as documented in Table 2-1 of **Appendix B**) given that the Phase 2 NSZD results confirm that NSZD losses are much greater than what can be currently recovered.



7 References

- CRC CARE. (2015). A practitioner's guide for the analysis, management and remediation of LNAPL. CRC CARE Technical Report 34. Adelaide, Australia: CRC for Contamination Assessment and Remediation of the Environment.
- CRC CARE. (2018). Technical measurement guidance for LNAPL natural source zone depletion. CRC CARE Technical Report 44. Adelaide, Australia: CRC for Contamination Assessment and Remediation of the Environment.
- EHS Support. (2020). LNAPL CSM and Remedial Action Work Plan. St. Croix Alumina Site, St. Croix, U. S. Virgin Islands. July.
- EHS Support. (2021a). LNAPL Natural Source Zone Depletion Work Plan. St. Croix Alumina Site, St. Croix, U. S. Virgin Islands. April.
- EHS Support. (2021b). Phase 1 Natural Source Zone Depletion Assessment Report. St. Croix Alumina Site, St. Croix, U. S. Virgin Islands. December.
- Garg, S., C.J. Newell, P.R. Kularni, D.C. King, D.T. Adamson, M.I. Renno, and T. Sale. (2017). Overview of Natural Source Zone Depletion: Processes, Controlling Factors, and Composition Change. Groundwater Monitoring & Remediation 37(3), 2017.
- HOVIC. (2001a). St. Croix Alumina Site. Draft Phase Separated Petroleum Hydrocarbon (PSPH) Plume Remediation Work Plan. July 23.
- HOVIC. (2001b). Draft Dissolved Phase Petroleum Hydrocarbon (DPPHC) Work Plan. September 21.
- HOVIC. (2001c). Draft Dissolved Phase Petroleum Hydrocarbon (DPPHC) Work Plan (revised). December 21.
- HOVIC. (2002). Draft Dissolved Phase Petroleum Hydrocarbon (DPPHC) Work Plan (revised). February 22.
- HOVIC. (2018a). Draft PSPH Pilot Study and DPPHC Sampling Plan Modification. May 21.
- HOVIC. (2018b). Final PSPH Pilot Study and DPPHC Sampling Plan Modification. June 11.
- ITRC. (2009). Evaluating natural source zone depletion at sites with LNAPL. Interstate Technology and Regulatory Council, LNAPLs Team. http://www.itrcweb.org/GuidanceDocuments/LNAPL-1.pdf
- Sweeney, R.E. and G.T. Ririe. (2017). Small purge method to sample vapor from groundwater monitoring wells screened across the water table. Groundwater Monitoring & Remediation, 37(4), pp.51-59.
- USEPA. (2002). Letter of Approval for Draft DPPHC Work Plan. January 15.

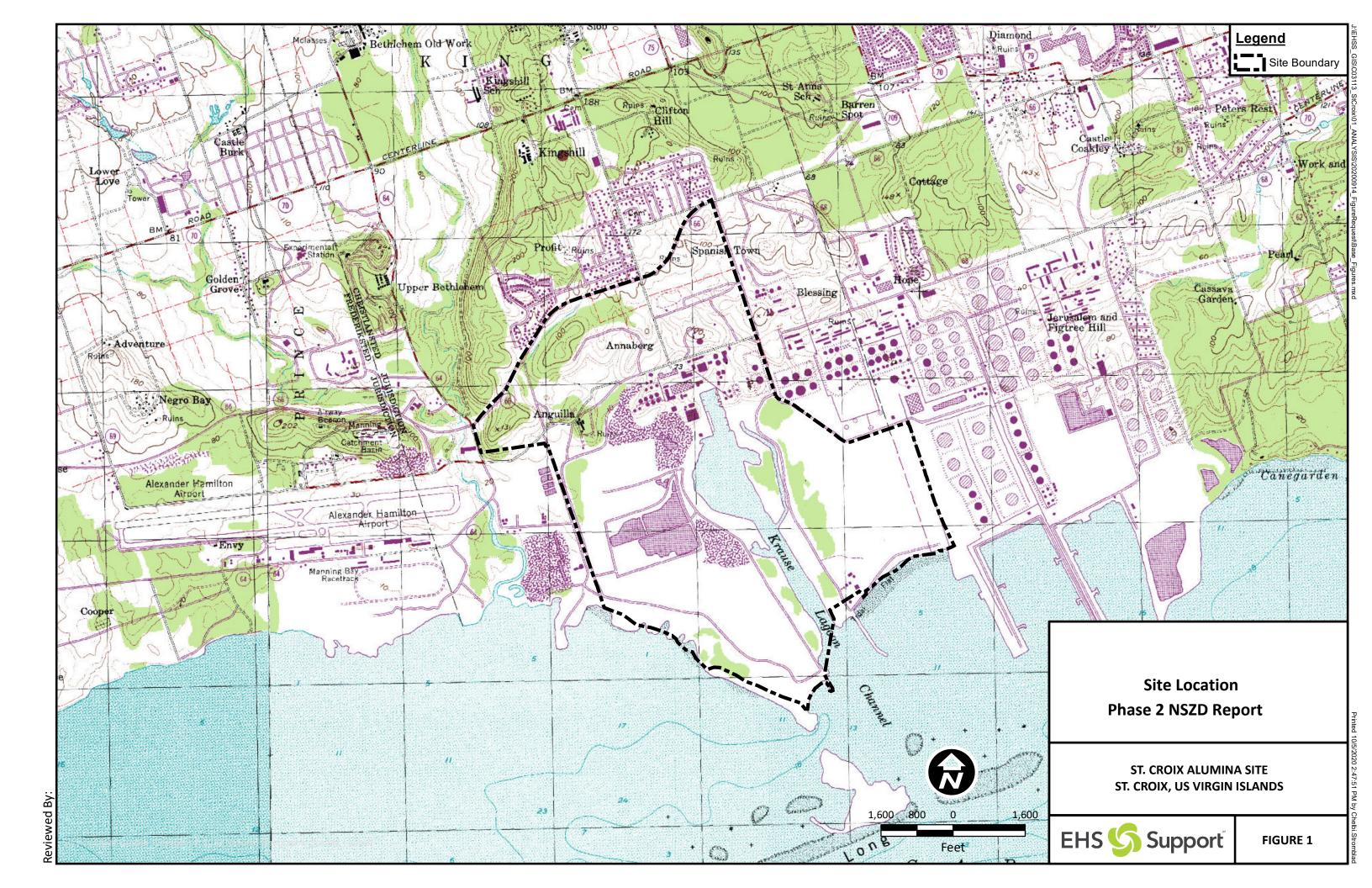
Phase 2 Natural Source Zone Depletion Assessment Report – St. Croix, U.S. Virgin Islands References

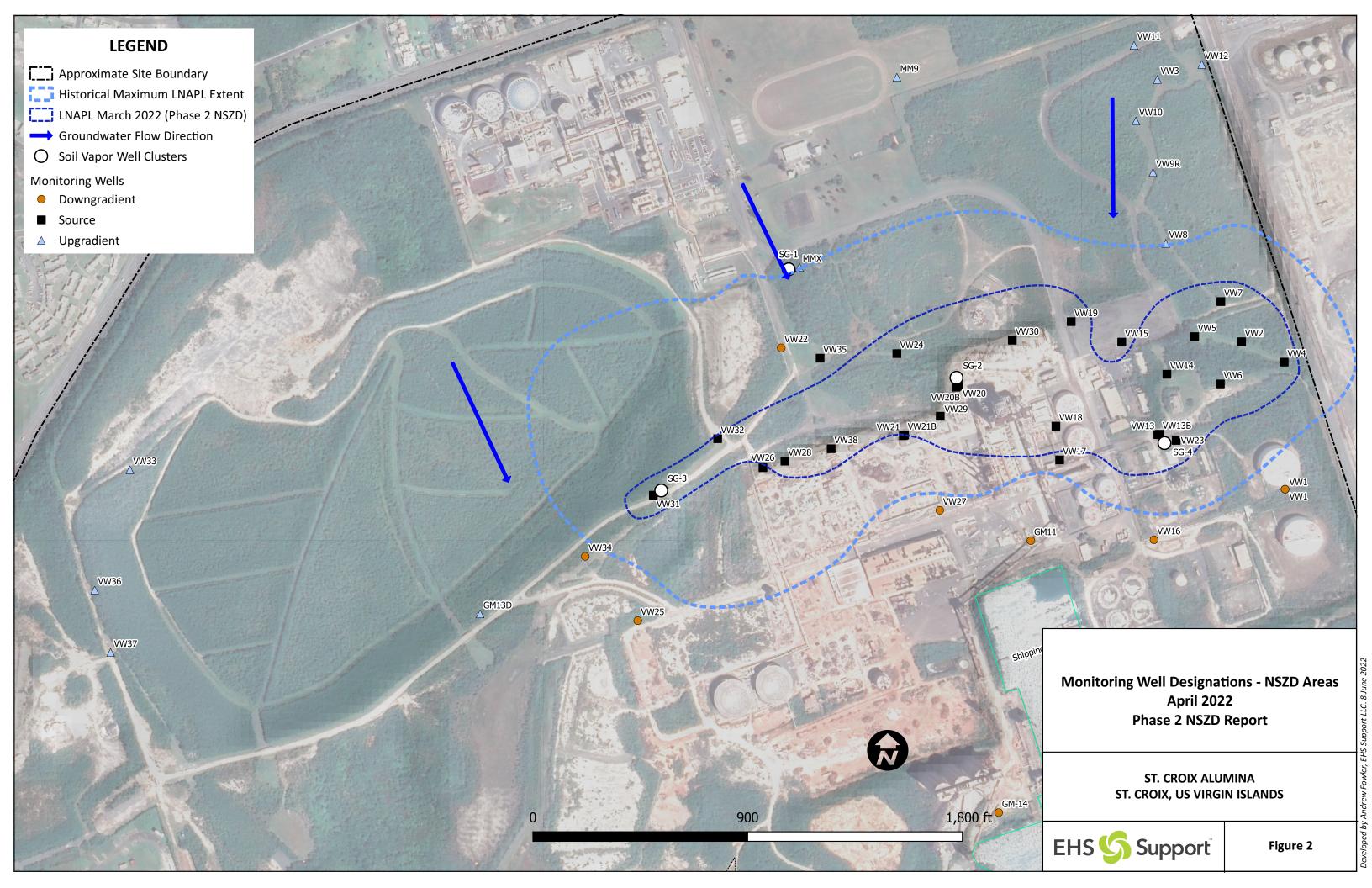


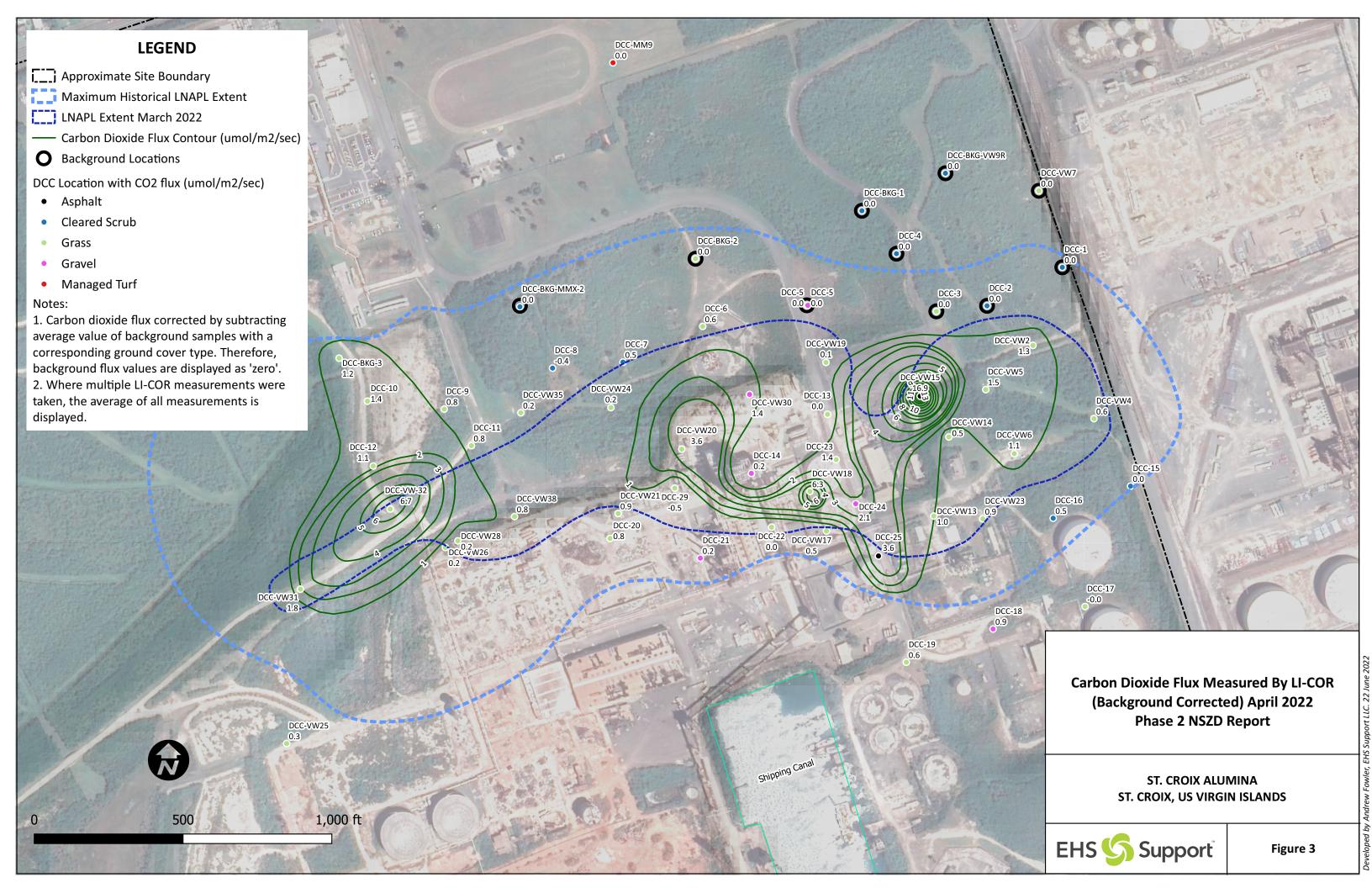
USEPA. (2005). A Decision-Making Framework for Cleanup of Sites Impacted with Light Non-Aqueous Phase Liquids (LNAPL) (EPA 542-R-04-011). March.

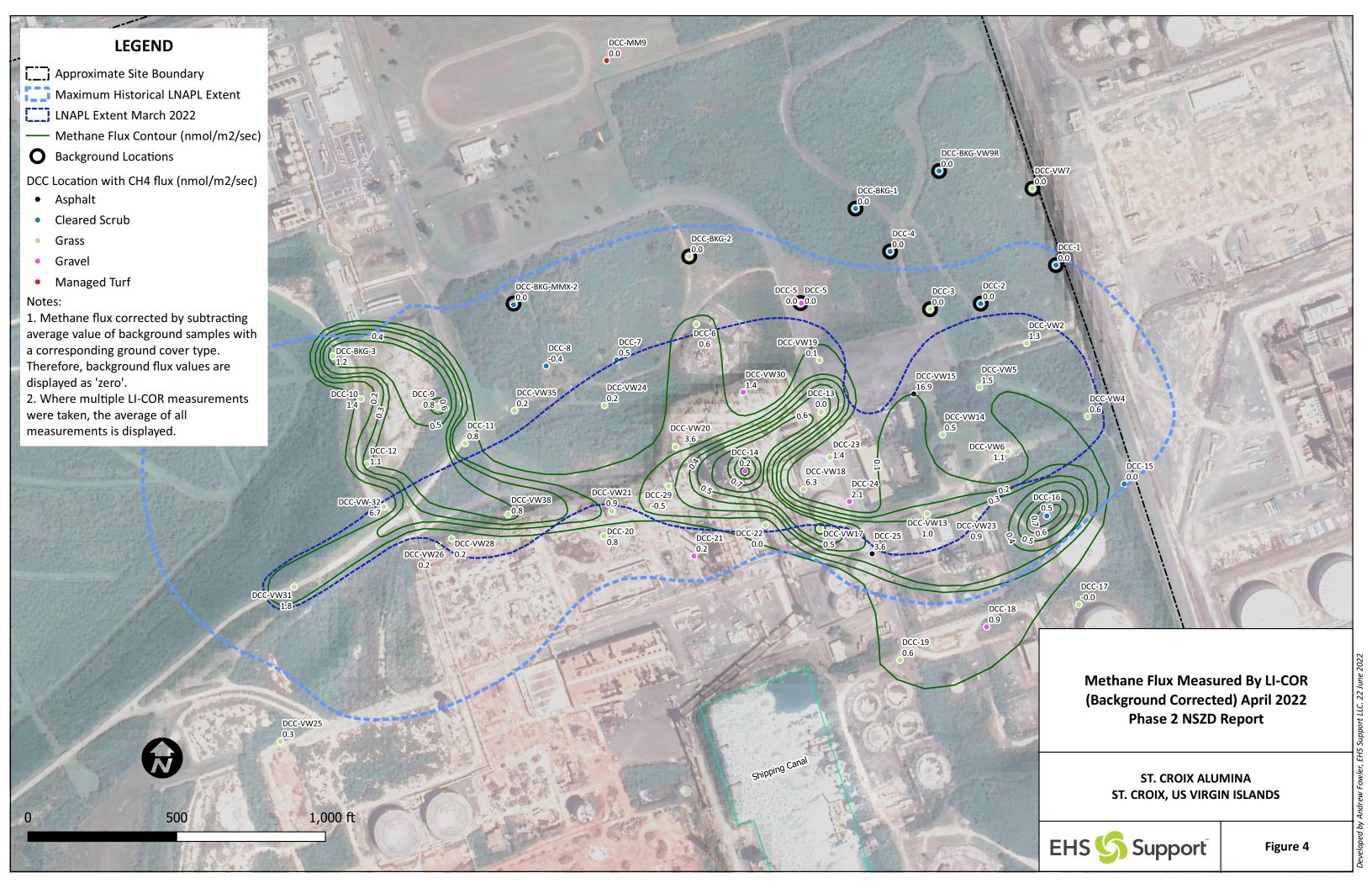


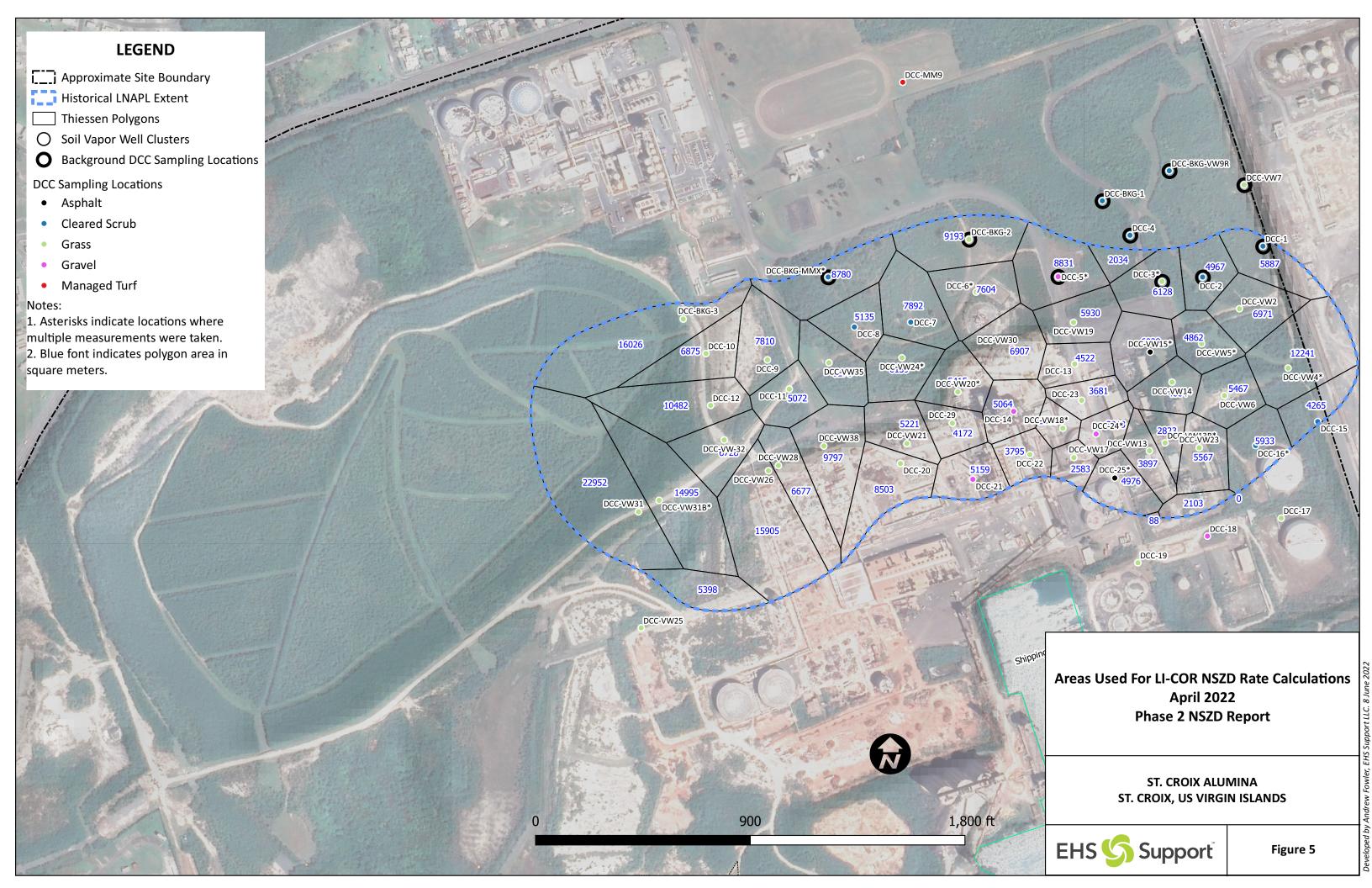
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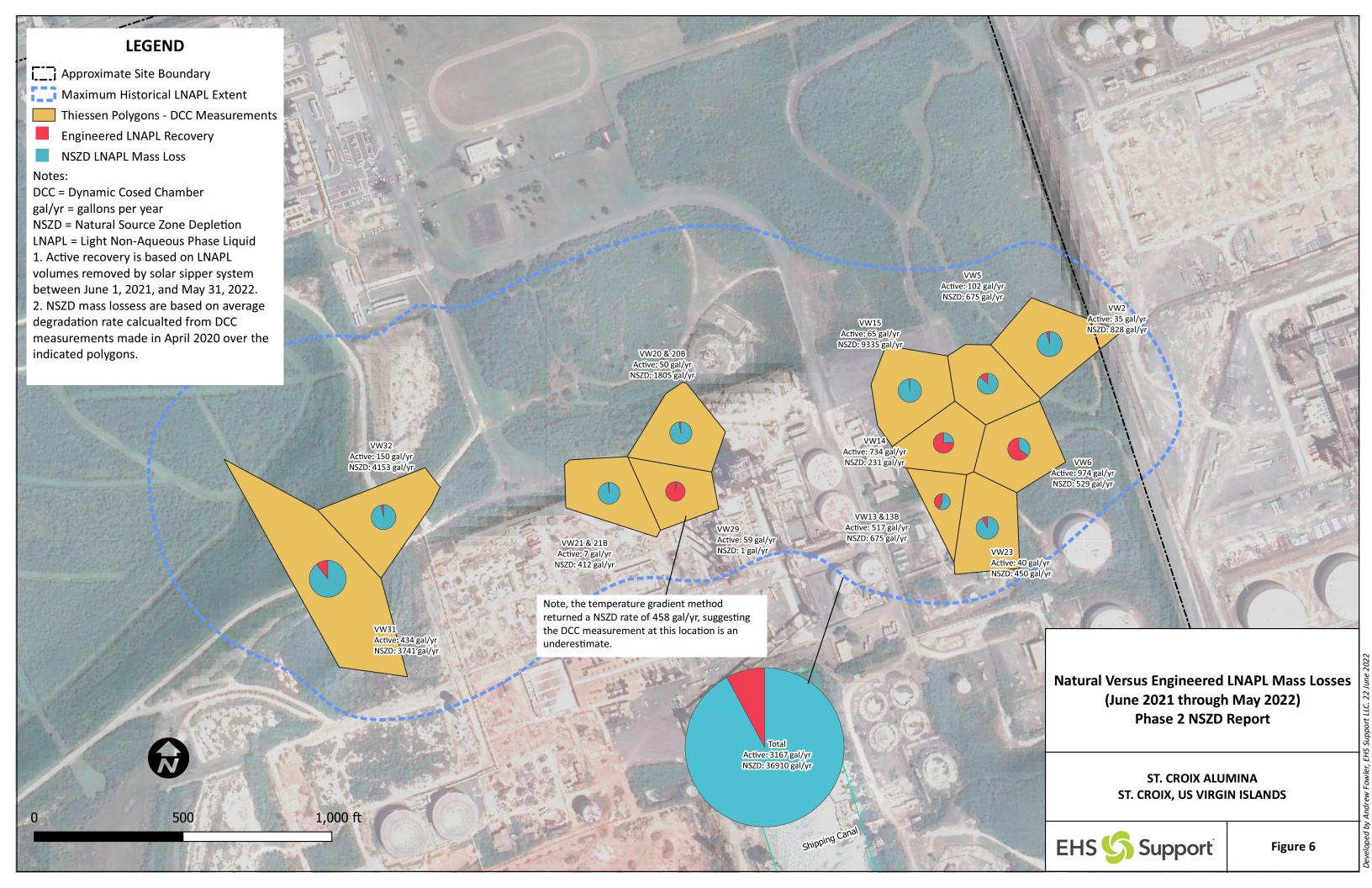














Appendix A Detailed Phase 2 NSZD Results and Calculations

Appendix A: Detailed
Phase 2 Natural Source
Zone Depletion
Calculations and
Results
St. Croix, U.S. Virgin
Islands

Prepared for:

St. Croix Alumina Site

Prepared by:



August 2022



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EHS Support LLC iii

Appendix A: Detailed Phase 2 Natural Source Zone Depletion Calculations and Results – St. Croix, U.S. Virgin Islands Acronyms



Acronyms

 $^{\circ}$ C degrees Centigrade ΔH° standard enthalpy

ΔT temperature difference

 μ mol micromoles $C_{18}H_{38}$ octadecane CH_4 methane

CO₂ carbon dioxide

CSM Conceptual Site Model
DCC dynamic closed chamber

DPPHC dissolved phase petroleum hydrocarbon constituents

DQO data quality objective

ft feet

ft/ft feet per foot g/mol grams per mole

GAM generalized additive model
GMS Geomonitoring Services

H⁺ hydrogen H₂O water

HCO₃ bicarbonate

ITRC Interstate Technology & Regulatory Council

J Joules

K hydraulic conductivity

kg kilogram kJ kilojoules

LNAPL light non-aqueous phase liquid

m meter

m² square meters m³ cubic meters

m³m cubic meters per meter

mL milliliter

MNA monitored natural attenuation

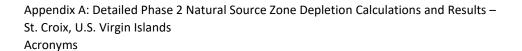
mol moles

NAPL non-aqueous phase liquid

nmol nanomole

NSZD natural source zone depletion

O₂ oxygen





POC Project Operating Committee

PSPH phase separated petroleum hydrocarbons

q_H heat flux

QA quality assurance

QAPP Quality Assurance Project Plan

QC quality control

R² correlation coefficient
RSE residual standard error

sec second

SS sum of squares

USEPA United States Environmental Protection Agency

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Appendix A: Detailed Phase 2 Natural Source Zone Depletion Calculations and Results – St. Croix, U.S. Virgin Islands
Introduction



1 Introduction

The purpose of this Appendix to the Phase 2 NSZD Study Report is to document detailed results and calculations of a Phase 2 natural source zone depletion (NSZD) study. This study addresses the magnitude of NSZD processes affecting phase separated petroleum hydrocarbons (PSPH) and dissolved phase petroleum hydrocarbon constituents (DPPHC) located beneath the St. Croix Alumina facility in St. Croix, U.S. Virgin Islands ("Site"; Figure A-1).

1.1 Background

EHS Support LLC ("EHS Support") developed and submitted an NSZD Work Plan ("Work Plan") to United States Environmental Protection Agency (USEPA) in April 2021 (EHS Support, 2021a). The objective of the Work Plan was to provide the protocols and procedures for a geohydrology and geochemistry assessment to facilitate a better understanding of, and to quantify the natural attenuation degradation of, the historical dissolved and phase-separated impacts in groundwater at the Site. EHS Support proposed an iterative process consisting of two phases that use a combination of existing monitoring well geochemistry data and soil gas flux analysis in accordance with established NSZD and monitored natural attenuation (MNA) technical guidance (Interstate Technology & Regulatory Council [ITRC], 2009; CRC CARE, 2015 and 2018).

The objective of the Phase 1 NSZD Study was to develop a better understanding of and to provide a preliminary quantification of natural attenuation and degradation of the historical DPPHC and PSPH impacts in groundwater at the Site to inform the approach for the Phase 2 works. Results of the Phase 1 NSZD Study were submitted to USEPA in a report dated September 30, 2021 (EHS Support, 2021b). USEPA provided comments on the Phase 1 NSZD Study Report in a letter dated November 1, 2021. A response to the USEPA comments was provided in a letter dated December 7, 2021. USEPA accepted the response to comments in a letter dated January 28, 2022, which also contained additional comments and a request for clarification. The January 28, 2022 letter confirmed key agreements were acceptable, including the provision that comments from USEPA and their contractor on the Phase 1 NSZD Study Report would be incorporated into this Phase 2 NSZD Study Report.

1.2 Phase 2 Objectives

The objective of this Phase 2 NSZD Study was to use of advanced methods to quantify mass depletion rates. A dynamic closed chamber (DCC) study using a LI-COR meter was selected as the optimal means for acquiring high-resolution NSZD rate data as it allowed for the densest sampling grid. Unlike other alternatives, the use of a LI-COR meter also provided the flexibility to assess if methane is fully degraded in the subsurface. To provide additional lines of evidence, the following were completed:

- Four clusters of multilevel soil vapor sampling wells (SG-1 through SG-4) were installed to assess NSZD rates using the gas gradient method.
- Temperature measurements were taken at multiple depths in monitoring wells to quantify NSZD rates using the temperature gradient method.
- Monitoring well headspace readings were taken as a qualitative verification of the DCC results.

Appendix A: Detailed Phase 2 Natural Source Zone Depletion Calculations and Results – St. Croix, U.S. Virgin Islands
Introduction



The goals of the Phase 2 NSZD Study were designed to confirm the degree to which NSZD depletion is active at the Site using higher-resolution sampling methods than were implemented during the qualitative Phase 1 NSZD Study. The following multiple lines of evidence were evaluated to establish evidence for active NSZD during the Phase 2 NSZD Study:

- 1. Qualitatively confirm NSZD processes are occurring at the Site through observation of elevated temperature and biogenic gases in source area wells (elevated carbon dioxide, methane, and/or hydrogen sulfide; depleted oxygen).
- 2. Calculate high-resolution NSZD rates using the DCC method.
- 3. Support calculated DCC NSZD rates using gas gradient measurements from multi-level soil vapor probes and multi-level temperature measurements in monitoring wells.

1.3 USEPA Comments on Phase 1 NSZD Study Report and Scope and Reporting Changes Integrated into Phase 2 NSZD Study Report

The following USEPA comments on the Phase 1 NSZD Study Report (EHS Support, 2021b) were addressed in this Phase 2 NSZD Study Report:

- Verify and quantify the flux of carbon dioxide and methane at ground surface using DCC methods.
- Quantify the contribution or bias to NSZD rates due to methane flux at ground surface using DCC methods.
- Modify the DCC grid proposed in the Phase 1 NSZD Study Report to cover a broader area including paved locations. The grid was expanded to include 56 locations.
- Include additional background DCC monitoring locations to those originally proposed in the Phase 1 NSZD Study Report.
- Include DCC monitoring locations adjacent to each monitoring well, where surface conditions allow.
- Provide a temporal comparison of NSZD rates to confirm consistency of results over time, with the acknowledgment that annual temperature and climate variations are minimal in the St.
 Croix climate compared to temperate locations where NSZD may vary.
- Install four multi-level soil gas monitoring locations to assess the vertical concentration profiles of subsurface gases as an additional line of evidence for NSZD.
- Provide text describing the rationale for the selected soil gas monitoring locations.
- Seal the soil gas probe boreholes with grout instead of bentonite slurry, and install monitoring points in individual boreholes instead of a common borehole to prevent potential gas leakage due to desiccation of bentonite seals.
- Include a table describing decision criteria based on each NSZD assessment method.
- Demonstrate that the DCC method is representative of NSZD rates determined for similar Sites elsewhere, and provides high spatial coverage compared to alternate preferred methods for assessing the consistency of NSZD results.
- Verify if geological and surface cover conditions affect gas flux measured by DCC.
- Account for potential geologic effects on temperature gradient NSZD rates by revising how measurements are parceled.
- Use non-averaged data for temperature gradient calculations in locations where reductions in, or discontinuation of, pumping allows.

Appendix A: Detailed Phase 2 Natural Source Zone Depletion Calculations and Results – St. Croix, U.S. Virgin Islands
Introduction



- Use multiple lines of evidence to calculate NSZD rates, given the temperature gradient and gas gradient methods use some non-site-specific data.
- Assess potential biases on NSZD rate determination techniques.
- Provide details on how upgradient, source area, and downgradient well designations provided in the Phase 1 NSZD Study Report were determined, including a revised map that indicates the groundwater flow direction and PSPH affected area.

USEPA also requested that DCC results be presented by overlaying results with geology interpretations. However, upon review of Phase 2 NSZD Study data and results, it was found that the most informative approach is to overlay results with the light non-aqueous phase liquid (LNAPL) distribution measured immediately before the DCC event. As discussed in **Section 5.4**, DCC results coincide with LNAPL distribution as opposed to subsurface geological variations. Therefore, DCC results are provided overlain on LNAPL distribution maps. Limestone outcrops and excavation faces exposed at the Site and shown to USEPA during their Site visit in May 2022 reveal highly porous and interconnected void spaces (**Figure 1-2**). Field verification of laterally extensive and highly porous limestone implies geologic heterogeneity has little effect on calculated NSZD rates. Therefore, rigorous statistical and graphical analyses of the effects of geologic variations on NSZD rate calculations were not implemented in this Phase 2 NSZD Study.





1. Image of Kingshill Limestone at the Site. Excavation cut extends approximately from VW26 to between VW19 and VW30. Although not exposed in an excavation cut, the same rock type is expected to be present across the LNAPL affected area. 2. Fingers for scale in inset image of Kingshill Limestone.

Figure 1-2 Photograph of porous limestone exposed in excavation cut at the Site (April 2022).



2 Phase 2 Tasks

For consistency between this Phase 2 NSZD Study and the Phase 1 NSZD Study, source area wells were designated as those that had LNAPL present during the last quarter of 2019. The criteria for selecting upgradient wells are those located hydraulically upgradient or side-gradient to the LNAPL plume. Source area wells are those that have measured LNAPL. Downgradient wells are those that are immediately adjacent to the LNAPL affected area or hydraulically downgradient. Upgradient, source area, and downgradient well designations are shown on **Figure A-2**.

The Phase 2 work consisted of the following field tasks:

- **Temperature Profiling** A downhole temperature profiling assessment was completed in the unsaturated and saturated zones to determine the temperature gradient at the selected wells. Results are provided in **Table A-1**.
 - Five unsaturated zone temperature readings were measured at each well (2 feet [ft] below ground surface, 1 ft above groundwater, and three intervals equally spaced in between).
 - Three saturated zone temperature readings were completed at each well (1 ft below the groundwater interface, 5 ft below the groundwater surface, and 10 ft below the groundwater surface).
- Well Headspace Gas Deep vadose methane, carbon dioxide, and hydrogen sulfide gas
 concentrations were measured 1 foot above the water table in all wells where temperature
 profiles were completed following the technique of Sweeney and Ririe (2017). Oxygen was also
 measured in wells adjacent to newly installed multi-level soil gas monitoring points. Results are
 provided in Table A-1.
- Multi-level Soil Vapor Soil Gas Four clusters of multi-level soil gas monitoring points (SG-1 through SG-4) were installed adjacent to existing monitoring wells MMX, VW20, VW31, and VW13, respectively (Figure A-2). The locations adjacent to wells afforded the ability to collect a deep soil gas measurement immediately above the liquid level in the well and minimize the possibility of groundwater periodically flooding the deep vapor point in each cluster. The generalized construction of each soil vapor point cluster consisted of four sampling points installed in adjacent borings at the following depths:
 - 5 feet above the groundwater table (targeting the sand unit present at or above most screened intervals)
 - o ¼ distance between the ground surface and the top of the well screen
 - o 34 distance between the ground surface and the top of the well screen
 - 5 feet below ground surface

Methane, carbon dioxide, hydrogen sulfide, and oxygen were measured at each sampling point on May 3, 2022, and May 5, 2022; results are provided in **Table A-2**.

• DCC measurements using a LI-COR meter — Ground surface methane and carbon dioxide flux were measured at 57 locations. Locations were selected to represent a range of ground surface cover types. Measurements were made at different times and on different days at several locations to verify temporal gas flux stability (Table A-3).

Appendix A: Detailed Phase 2 Natural Source Zone Depletion Calculations and Results – St. Croix, U.S. Virgin Islands
Field Measurement and Sampling Procedures



3 Field Measurement and Sampling Procedures

Detailed field and sampling procedures are provided in the Work Plan (EHS Support, 2021a), which was submitted to USEPA in April 2021; and in the Phase 1 NSZD Study Report (EHS Support, 2021b), which was submitted to USEPA in December 2021. The Project Operating Committee (POC) lead contractor (Geomonitoring Services [GMS]) and EHS Support performed Site investigation activities in accordance with the Health and Safety Plan developed for the Site (GMS, 2020).

Instruments used to collect data were calibrated according to manufacturer specifications as applicable. The DCC calibration record is provided in **Attachment A1**. Reusable and non-dedicated instruments and equipment were decontaminated between sampling locations according to procedures outlined in the Work Plan. Disposable equipment was decontaminated, and decontamination fluid and spoils were managed as investigation-derived waste.

Well headspace gas (carbon dioxide, methane, and hydrogen sulfide) concentrations, downhole temperatures, and fluid levels were measured before collecting samples or disturbing wells as part of other activities. Results are provided in **Table A-1**. Groundwater elevation contours are provided on **Figure A-3** and PSPH thickness contours are provided on **Figure A-4**. The spatial distribution and contours of downhole temperatures and well headspace gases are compared to the April 2022 PSPH extent on **Figure A-5** through **Figure A-9**.

No waste liquid was generated from sampling and measurement activities.



4 Phase 2 Qualitative NSZD Results

The Phase 1 NSZD Study Report (EHS Support, 2021b) was designed to qualitatively confirm the degree to which NSZD depletion is active at the Site. Multiple lines of evidence provided in the Phase 1 NSZD Study Report support the occurrence of robust NSZD processes at the Site with groundwater geochemistry and electron acceptors indicating that sulfate reduction and methanogenesis are the dominant mass loss mechanisms.

To provide a point of comparison with the Phase 1 NSZD Study and to demonstrate the long-term stability of NSZD processes, the following multiple lines of qualitative evidence for active NSZD processes were evaluated during the Phase 2 NSZD Study:

- 1. Elevated temperature in the vadose zone (i.e., 1 foot above groundwater) is an indicator of volatile phase exothermic NSZD reactions (**Figure A-5**).
- 2. Elevated temperature in the saturated zone (i.e., 1 foot below groundwater) is an indicator of aqueous and volatile phase exothermic NSZD reactions (**Figure A-6**).
- 3. Biogenic gases were identified in source area wells (elevated methane, carbon dioxide, and hydrogen sulfide) (Figure A-7 through Figure A-9, respectively).

Consistent with the results of the Phase 1 NSZD Study, qualitative results from the Phase 2 NSZD Study demonstrate robust NSZD processes at the Site with elevated methane and carbon dioxide gas concentrations in the vadose zone (elevated hydrogen sulfide in some source locations), and elevated groundwater and vadose temperatures in the source zone. These results are consistent with methanogenesis being the dominant mass loss mechanism in the source area, with sulfate reduction contributing in some areas.

Qualitative assessment methods and results are provided in the following sections.

4.1 NSZD Assessment Using the Differential Temperature Method

Methane produced from LNAPL volatilization and methanogenesis exothermically reacts with oxygen in the unsaturated zone to produce carbon dioxide (CRC CARE, 2015). Temperature measurements can be used to identify biogenic (metabolic) heat signatures resulting from methane biodegradation in the source zone as evidence for NSZD (Garg et al., 2017; Newell et al, 2016; Suthersan et al., 2015; Warren and Bekins, 2015; Sweeney and Ririe, 2014).

Temperatures in the background, LNAPL source area, and downgradient locations of the Site were measured using a calibrated thermocouple lowered down the well casing to the intervals specified in **Table A-1**. The thermocouple was lowered to the specified monitoring depths within the unsaturated zone for a minimum of three minutes and in the saturated zone for a minimum of one minute before lowering to the subsequent monitoring depth, following the procedure of Sweeney and Ririe (2014).

Contour maps of temperature measurements in the vadose zone 1 foot above the water table and in the saturated zone 1 foot below the water table are provided in **Figure A-5** and **Figure A-6**, respectively. The temperature contours qualitatively show elevated temperatures in source area wells compared to upgradient (background) wells in both the saturated and unsaturated zones. As shown on the contour



maps, anomalously high vadose temperatures were observed at wells MMX and MM9 compared to other background locations; therefore, these two wells are not considered in the background correction for quantitative calculation of NSZD rates using the temperature gradient method.

To verify the above interpretation of temperature contour maps, the net temperature difference (ΔT) between source and background wells was calculated to qualitatively assess metabolic heat signatures from LNAPL degradation 1 foot above and 1 foot below the water table:

$$\Delta T = Ti - Tb$$

Where:

Ti is the temperature of well i.

Tb is the temperature of background well b.

The calculation was also performed to compare ΔT between source and downgradient wells. The calculation was performed for the maximum, average, and minimum background groundwater temperatures for all monitoring zones. Results are tabulated in **Table A-4** and provided as histograms for the intervals 1 foot above and 1 foot below the water table (intervals nearest the typical locus of methane oxidation) on **Figure 4-1** and **Figure 4-2**. Positive values indicate elevated temperatures in the source area relative to background or downgradient wells.

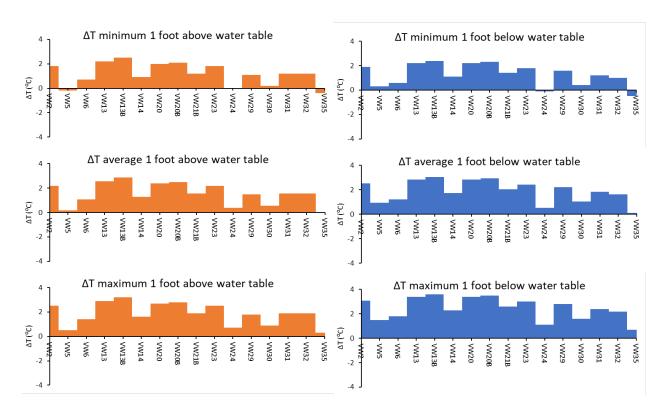


Figure 4-1 Histogram of minimum, average, and maximum temperature differences between source area and background well locations 1 ft above water table and 1 ft below water table.



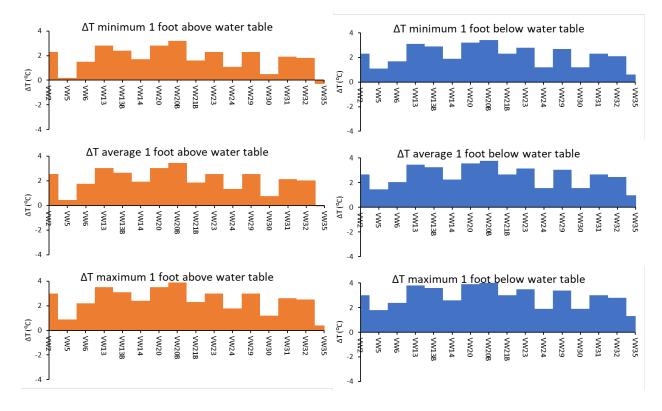


Figure 4-2 Histogram of minimum, average, and maximum temperature differences between downgradient and background well locations 1 ft above water table and 1 ft below water table.

As indicated on **Figure 4-1**, elevated temperatures are present in all source zone wells relative to background 1 ft above and 1 ft below the water table using the minimum, average, and maximum ΔT scenarios. As indicated on **Figure 4-2**, temperatures downgradient of the source area are generally elevated relative to background locations but not to the magnitude observed in source area wells. This observation suggests there is some heat flux from the source area to the downgradient areas, however, the heat source wanes consistent with the absence of LNAPL in downgradient locations.

Qualitative temperature measurements support that oxidation of methane produced by LNAPL degradation is occurring in the source area and provides a source of heat. These observations are consistent with the results of the Phase 1 NSZD Study (EHS Support, 2021b) and suggest that LNAPL degradation processes have remained stable in the time between the Phase 1 NSZD Study and the Phase 2 NSZD Study.

4.2 NSZD Assessment Using Well Headspace Gas Data

Headspace readings in the background, source area, and downgradient monitoring wells were measured by inserting a calibrated, hand-held, multi-gas meter capable of measuring hydrogen sulfide, carbon dioxide, and methane into each well. One measurement was recorded 2 ft below the top of casing and one measurement 1 ft above the water table. The measurement taken 2 ft below the top of casing was to verify the meter was operating correctly and to allow for stabilization before taking the measurement



1 ft above the water table. Data from 1 ft above the water table were utilized for qualitative and quantitative NSZD calculations.

The qualitative NSZD headspace gas assessment compared gas (carbon dioxide, methane, and hydrogen sulfide) concentrations in the background and source areas to identify statistically significant differences. Elevated concentrations of methane, carbon dioxide, and hydrogen sulfide were identified in the source area compared to background locations (**Figure A-7** through **Figure A-9**). Differences in gas concentrations between background, source area, and downgradient wells were assessed using box and whisker plots (**Figure 4-3**). The box and whisker plots indicate elevated concentrations of all three gases in the source area and downgradient wells compared to background wells.

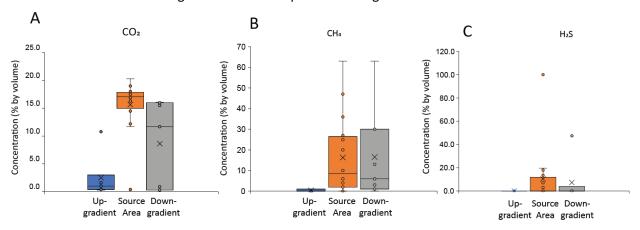


Figure 4-3 Box and whisker plots of well headspace gas concentrations.

A statistical analysis including parametric and non-parametric methods for comparison of source and background areas (i.e., t-test and Wilcoxon rank-sum test) was used as an additional line of evidence to show that gas concentration differences in source area wells were statistically significant, following the procedures outlined in USEPA (2009). An F-test was used to determine if variances of the two populations (background and source area samples) were equal. The F-test indicated that variances of concentration populations for all three gases are unequal in the source area and background wells (**Table A-5**). Therefore, a two-sample t-test assuming unequal variances was applied. The two-sample t-tests confirmed a statistically significant difference in the mean concentrations of methane and carbon dioxide gases in the source area compared to background wells. Non-parametric Wilcoxon rank-sum tests indicated that there are statistically significant greater concentrations of all three gases in the source area compared to background locations.

In summary, well headspace gas measurements provide qualitative evidence for robust NSZD in the LNAPL source area.

The presence of percent by volume methane and carbon dioxide concentrations and the detection of hydrogen sulfide 1 ft above groundwater in the source area and downgradient wells indicates that robust NSZD processes are occurring at the Site. As indicated in the aerial photo and gas contours on **Figure A-7** through **Figure A-9**, elevated gas concentrations occur in both vegetated and paved areas of the Site, which indicates that gas accumulation is not driven by surface cover conditions. The magnitude of methane concentrations suggests methane oxidation to carbon dioxide in the subsurface may be



incomplete and methods based on temperature and carbon dioxide flux at ground surface will underestimate NSZD rates, as they will not account for methane that has not oxidized. Methods that measure both carbon dioxide and methane flux at ground surface are expected to provide a more accurate measure of NSZD rates in the unsaturated zone.

4.3 Summary of Qualitative Results

The following is a summary of qualitative NSZD results from the Phase 2 NSZD Study:

- Elevated unsaturated and saturated zone temperatures in the source area, compared to background locations, qualitatively indicate robust LNAPL degradation is occurring.
- Well headspace measurements of carbon dioxide, methane, and hydrogen sulfide are elevated in source area wells compared to background wells, confirming active NSZD is occurring.
- Qualitative NSZD indicators persisted between the Phase 1 NSZD Study and the Phase 2 NSZD Study, indicating that NSZD processes are temporally stable and are persistent.

A comparison of qualitative NSZD results between the Phase 1 and Phase 2 Studies is summarized in **Table 4-1**. The comparison indicates similar ranges in background and source area temperatures and gas concentrations between the Phase 1 and Phase 2 NSZD Study sampling events, and demonstrates temporal stability of NSZD processes.

Table 4-1 Comparison of Phase 1 and Phase 2 Qualitative NSZD Results

Qualitative Method	Phase 1 NSZD Study	Phase 2 NSZD Study		
Unsatu	rated Zone			
Well Temperature (Range of Background) (°C)	27.3 to 28.0	28.2 to 28.9		
Well Temperature (Range of Source Area) (°C)	28.5 to 31.4	27.7 to 31.2		
Background Carbon Dioxide (% vol)	0 to 11.0	0.3 to 10.8		
Background Methane (% vol)	0 to 1.0	0 to 1.0		
Background Hydrogen Sulfide (% vol)	0 to 0	0 to 0		
Source Carbon Dioxide (% vol)	1.7 to 16.1	0.4 to 20.3		
Source Methane (% vol)	0 to 65.0	0 to 63.0		
Source Hydrogen Sulfide (% vol)	0 to >100	0 to >100		
Saturated Zone				
Well Temperature (Range of Background) (°C)	27.7 to 28.9	27.2 to 27.9		
Well Temperature (Range of Source Area) (°C)	28.4 to 31.3	28.5 to 31.3		

Well unsaturated zone temperatures and gas concentrations from 1 foot above groundwater.

Well saturated zone temperatures from 1 foot below groundwater.

°C = degrees Centigrade

% vol = percent by volume

NSZD = natural source zone depletion



5 Phase 2 Quantitative NSZD Results

The following quantitative assessments of NSZD depletion rates were completed:

- 1. Unsaturated zone NSZD rate was estimated using vadose and groundwater temperature data.
- 2. Unsaturated zone NSZD rate was estimated using multi-level vadose samples of carbon dioxide, methane, and oxygen concentrations.
- 3. Unsaturated zone NSZD rate was estimated using direct measurements of carbon dioxide and methane flux at ground surface using DCC methods.

The aqueous NSZD rate calculated and provided in the Phase 1 NSZD Report. Calculations used for NSZD rates (R_{aq}) yield units of grams LNPAL per day. R_{aq} was divided by the estimated LNAPL density to obtain units of 'volume LNAPL depleted/year' and were converted to and reported as gallons/year using standard conversion factors. Calculation methods and results are provided in the following sections.

5.1 NSZD Rate Estimate Using Groundwater Temperatures

NSZD rate methods based on temperature generally only account for heat produced by methane oxidation in the unsaturated zone. However, a substantial amount of heat generated in the vadose zone may be transferred to groundwater and carried away by advection. Methods to calculate this portion of the heat generated by methane oxidation may be implemented and the result added to the NSZD rate calculated based on vadose temperature data (CRC CARE, 2015).

The NSZD rate was estimated from groundwater temperature data by calculating the power needed to heat a flowing volume of water. The method assumes homogenous and isotropic soil, a steady-state biogenic heat source, conductive heat transfer, and an instantaneous and complete reaction. The equation is widely used for geothermal heat pump applications (Arola et al., 2014; Herez et al., 2017):

$$P = \dot{m} \times C_p \times \Delta T$$

Where:

P = power required in Watts (Joules [J]/second [sec])

 \dot{m} = the groundwater mass flow rate (kilograms [kg]/sec)

 C_p = the specific heat of water (4,184 J/kg/Kelvin)

 ΔT = the groundwater temperature difference between source and background well groundwater 1 ft below the water table

In contrast to the aqueous NSZD calculation, mass flow rate rather than seepage velocity is considered in the groundwater heat calculation because a key variable is the enthalpy required to heat a given volume of water. Three scenarios were evaluated using the maximum (31.3°C), average (30.1°C), and minimum (28.5°C) source area groundwater temperatures 1 ft below the water table compared to the average background groundwater temperature (27.5°C) 1 ft below the water table. The groundwater mass flow rate (m) is the volumetric flow rate (m) is the volumetric flow rate (m) is the volumetric flow rate (m) is the density of water:

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$$\dot{m} = K \times i \times YZ \times \rho$$

Where:

K =the average hydraulic conductivity (meter [m]/sec)

i =the hydraulic gradient (unitless)

Y = Average width of the LNAPL footprint

Z = Average thickness of the LNAPL smear zone

 ρ = Density of water (ρ ; assumed to be 1,000 kg·m³)

Hydraulic conductivity (K) values were previously calculated from slug test data obtained from five site monitoring wells in different lithologies (GES, 2017) as discussed in the LNAPL Conceptual Site Model (CSM) and Remedial Action Work Plan (EHS Support, 2020). For NSZD rate calculations, the geometric mean of slug test data was calculated using the Bouwer and Rice method (50.4 ft/day [15.4 m/day]) were used in NSZD rate calculations.

The hydraulic gradient was calculated using water level elevations measured during the April 2022 Phase 2 field mobilization between wells VW10 and VW16. The result is a hydraulic gradient of 0.0007 feet per foot (ft/ft).

The *YZ* term is calculated from the following information:

- Average width of the LNAPL footprint (Y)
- Average height of groundwater supplying electron acceptors (Z)

The width of the LNAPL footprint was measured as the distance between the westernmost (VW32) and easternmost (VW4) wells where LNAPL was measured in July 2021 (2,396 ft [730.3 m]). The height of the groundwater flow zone supplying electron acceptors was assumed to be 10 ft (3.048 m), which is based on the interval of elevated temperatures measured beneath the source area described in **Section 4.1**.

The above parameters indicate a mass flow rate of \dot{m} = 0.277 kg/sec and required power to heat flowing groundwater of P = 1,159 J/sec (low estimate), P = 3,014 J/sec (average estimate), and P = 4,405 J/sec (upper estimate).

It is assumed that methane oxidation in the vadose zone provides the power source following the reaction (Warren and Bekins, 2015) (where CH_4 is methane, H^+ is hydrogen, H_2O is water, HCO_3 is bicarbonate, and O_2 is oxygen):

$$CH_{4(aq)} + 2O_{2(aq)} \rightarrow HCO_{3(aq)} + H^{+} + H_{2}O + Heat$$

The above reaction has an exothermic heat of reaction ΔH_r^0 = -865.4 kilojoules (kJ)/mole (mol) (Warren and Bekins, 2015). When corrected for the molar weight of methane, this yields 53,952.62 J/g of methane oxidized in the reaction.

Dividing the power (J/sec) by energy from the methane oxidation (J/g) gives methane the flux needed to heat groundwater by the observed temperature change (i.e., methane degradation rate) in units of g/sec. Multiplying the result by the stoichiometric ratio of 1.15 grams of octadecane degraded for each



gram of methane produced (as calculated in the Phase 1 NSZD Study; EHS Support, 2021b) gives the LNAPL degradation potential in units of grams per second. Multiplying this value by the density of octadecane (0.777 g/milliliter [mL]) gives the result in units of mL/second, which can be converted into other units using standard conversion factors. Lower-end, mean, and upper-end aqueous NSZD rate results based on this method are given units of gallons per year in **Table 5-1** and are compared to the results calculated as part of the Phase 1 NSZD Study. A detailed outline of the calculation method is provided in **Table A-6**.

Table 5-1 Site NSZD Rate Based on Groundwater Temperature

Aqueous NSZD Rates – Groundwater Temperature	Upper-End NSZD Rate	Mean NSZD Rate	Lower-End NSZD Rate
Gallons per Year (Phase 1 Results)	1,139	683	38
Gallons per Year (Phase 2 Results)	1,010	691	266

NSZD = natural source zone depletion

The results account for heat loss to groundwater, which is not included in the unsaturated zone temperature gradient method and is additive. The calculated rates in Phase 1 and Phase 2 Studies are very similar, indicating the stability of NSZD processes over time.

5.2 NSZD Rate Estimate Using the Differential Temperature Method

NSZD rates were calculated using the differential temperature method as described by CRC CARE (2018) and IRTC (2009 and 2018). The method assumes homogenous and isotropic soil, a steady-state biogenic heat source, conductive heat transfer, and instantaneous and complete reaction.

Heat flux is estimated using Fournier's first law of conduction, which is modified to estimate heat flux (q_H in units of joules per square meter per second [J/m²-soil/sec]:

$$q_H = K_T \left(\frac{\Delta T}{\Delta Z} \right)$$

Where:

 $\frac{\Delta T}{\Delta Z}$ = the temperature gradient (°Kelvin/m)

 K_T = the thermal conductivity of the soil (J/m/sec/Kelvin or W/m/Kelvin) in the hydrocarbon oxidation zone

Given high precipitation levels in the tropical climate, the average thermal conductivity for water-sorbed carbonate rocks of 3.54 W/m/Kelvin at 40.5°C from Thomas Jr. et al. (1973) was used in the calculation.

Background corrected temperature profiles were computed by subtracting the average background temperature profile from the source area temperature profiles. Given that temperature measurements were not taken at equal intervals above the water table, the background subtraction required fitting curves to the temperature profiles.



Measured temperature-depth profiles (Attachment A2.1) were first corrected to use the water table as a zero datum at each location (Attachment A2.2). Curves fitting to the result in Attachment A2.2 and equations describing each curve were calculated using the R statistical software package 'mgcv' (Wood, 2020). Both linear and generalized additive models (GAM) were tested, and the result providing the best fit to the data was used (Attachment A2.3). Model fit was determined based on the mean sum of squares (SS). In cases where the SS were similar for both modeled fits, professional judgment was used to identify the best fit model. Metrics describing the goodness of fit for the temperature profile models and the resulting equations describing the measured temperature profiles are provided in Table 5-2. Data points at 1-foot spacing along the fitted curves were then calculated, the background subtraction calculation was made at 1-foot intervals, and maximum and minimum points along the profile were identified. To complete the background subtraction, temperature models were fit for each of the five background wells using a linear or GAM model based on the description above. Predictions using the best fitting model were averaged for each depth interval above the water table for the five background wells to establish an average background curve for comparison to the source area wells. Each of the background wells contributed 20 percent of the average background model. Results of the background correction and selection of maximum and minimum points are provided in Table A-7 and shown graphically in Attachment A2.4.

Table 5-2 Goodness of fit statistics for temperature profile models

Well	Fit Type	Equation	Mean of the SS	RSE	Adj.R ²	p.value
VW10	GAM	Not applicable	0.057	0.163	0.951	3.35E-06
VW11	GAM	Not applicable	0.047	0.148	0.972	2.70E-06
VW13	GAM	Not applicable	0.091	0.191	0.9	7.04E-07
VW13B	GAM	Not applicable	0.044	0.132	0.973	2.15E-07
VW14	Linear	T = -0.07981 * H + 29.76815	0.068	0.15	0.974	1.16E-03
VW15	GAM	Not applicable	0.117	0.234	0.947	5.52E-06
VW16	Linear	T = 0.02357 * H + 31.10348	0.004	0.037	0.976	1.01E-03
VW18	Linear	T = -0.05564 * H + 29.90286	0.085	0.168	0.946	3.46E-03
VW2	Linear	T = -0.02842 * H + 30.37476	0.033	0.105	0.941	4.02E-03
VW20	Linear	T = -0.10019 * H + 30.71348	0.163	0.233	0.969	1.50E-03
VW20B	GAM	Not applicable	0.037	0.131	0.94	1.48E-06
VW21B	Linear	T = -0.05829 * H + 29.61157	0.008	0.05	0.996	7.88E-05
VW23	Linear	T = -0.09604 * H + 30.34836	0.094	0.177	0.966	1.71E-03
VW24	GAM	Not applicable	0.015	0.084	0.97	1.30E-06
VW25	Linear	T = -0.03732 * H + 27.83874	0.09	0.173	0.872	1.30E-02
VW27	Linear	T = -0.06431 * H + 28.79914	0.104	0.186	0.947	3.40E-03
VW29	Linear	T = -0.0903 * H + 30.3127	0.062	0.144	0.985	5.10E-04
VW3	GAM	Not applicable	0.034	0.129	0.983	3.55E-06
VW30	GAM	Not applicable	0.256	0.321	0.908	3.44E-06
VW31	Linear	T = -0.02671 * H + 29.83746	0.049	0.128	0.886	1.09E-02
VW32	Linear	T = -0.04137 * H + 29.74232	0.036	0.109	0.964	1.86E-03

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Well	Fit Type	Equation	Mean of the SS	RSE	Adj.R ²	p.value
VW34	Linear	T = -0.00389 * H + 28.16417	0.284	0.308	-0.316	8.55E-01
VW35	Linear	T = -0.04604 * H + 27.74443	0.049	0.128	0.982	6.46E-04
VW4	GAM	Not applicable	0.001	0.001	0.988	8.06E-08
VW5	Linear	T = -0.10908 * H + 28.31399	0.092	0.175	0.986	4.82E-04
VW6	GAM	Not applicable	0.096	0.196	0.924	7.13E-07
VW7	GAM	Not applicable	0.001	0.001	0.995	1.18E-07
VW8	GAM	Not applicable	0.022	0.102	0.98	1.18E-06
VW9R	GAM	Not applicable	0.013	0.081	0.992	1.43E-06

Adj. R² = Adjusted correlation coefficient

GAM = generalized additive model

H = height above the water table

p.value = measure of the probability that an observed difference could have occurred just by random chance

RSE = residual standard error

SS = sum of squares

T = temperature (degrees Centigrade)

The thermal gradient was then calculated from background-corrected temperature profiles shown in **Attachment A2.4**. The temperature profiles show that the shallowest depth interval in most wells is affected by surface temperature, resulting in a flattening of the profile at the ground surface that would result in an overestimation of the rate. Therefore, surface-affected areas were ignored in selecting the shallowest point used in the temperature gradient calculation, where present. Input for the $\frac{\Delta T}{\Delta Z}$ are given in **Table A-8**.

The NSZD rate (R_{NSZD}) is then calculated by dividing the calculated heat flux by the enthalpy (ΔH^0) of octadecane oxidation. The enthalpy of octadecane oxidation is calculated using the stoichiometry of octadecane oxidation following the method described in Sweeney and Ririe (2014) that is based on the following equation (where $C_{18}H_{38}$ is octadecane and CO_2 is carbon dioxide):

$$C_{18}H_{38} + 27.5O_2 = 18CO_2 + 19H_2O$$

The following enthalpies of formation of the reaction components at standard state (in kJ/mol at 298.15 Kelvin), where ΔH_f^0 is the standard-state heat of formation:

- $\Delta H_f^0_{C18H38} = -414.6 \text{ kJ/mol}$
- $\Delta H_f^0_{O2} = 0 \text{ kJ/mol}$
- $\Delta H_f^0_{CO2} = -393.5 \text{ kJ/mol}$
- $\Delta H_{f}^{0}_{H2O} = -285.8 \text{ kJ/mol}$

By solving for the standard enthalpy of the reaction, [i.e., $\Delta_r H^\circ = \Sigma v \Delta_f H^\circ$ (products)— $\Sigma v \Delta_f H^\circ$ (reactants)], ΔH_r^o of the above reaction is -12092.9 kJ/mol, which when divided by the molar weight of octadecane (254.5 grams per mole [g/mol]) gives 47.5 kJ/g of heat released. Therefore, the NSZD degradation rate (in grams/m²/day) is:

$$R_{NSZD} = \frac{q_H}{47500 \, kI/g} \times \frac{86,400 \, sec}{1 \, d}$$

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Where: d = daykJ/g = kilojoules per gram

 q_H = heat flux sec = second

Calculation results are given in Table A-8.

R_{NSZD} was then multiplied by an area representative of each location. The area representative of each location was determined by calculating Thiessen polygons for monitoring wells where temperatures were sampled, and constraining the extent to the historical maximum LNAPL footprint (Figure A-10). The area of the resulting polygons was then extracted from the geographic information systems shapefile and multiplied by the value of R_{NSZD} to give a value for each location of LNAPL degraded in g/day. The sum of g/day values was then converted to units of gallons/year using the LNAPL density. Detailed calculation results are given in Table A-8 and are summarized on Table 5-3. Results indicate an unsaturated zone NSZD rate of 11,737 gallons per year.

In summary, vadose temperature profiles indicate active, robust LNAPL NSZD is occurring, and the magnitude is substantially higher than calculated for the saturated zone, which is in concurrence with values obtained for sites elsewhere (Garg et al., 2017). Mass depletion rates calculated using the temperature gradient method are a similar order of magnitude between the Phase 1 and Phase 2 Studies, indicating mass depletion rates are stable over time.

Table 5-3 **Site NSZD Rate Based on Temperature Gradient Method**

Aqueous NSZD Rates – Temperature Gradient Method	NSZD Rate (Gallons per year)
Gallons per Year (Phase 1 Results)	7,137
Gallons per Year (Phase 2 Results)	11,737

NSZD = natural source zone depletion

5.3 NSZD Rate Estimate Using the Gas Gradient Method

The gas gradient method uses differences in oxygen or carbon dioxide concentrations between upper and lower control points in the subsurface, divided by the vertical distance between the control points to determine a vertical gas concentration gradient. The vertical concentration gradient is then used to calculate diffusive gas flux using Fick's law and is stoichiometrically converted to an NSZD rate.

$$J = D_v^{eff} \left(\frac{\Delta C}{\Delta Z} \right)$$

Where:

 $J = \text{steady state diffusive flux (g/m}^2/\text{sec)}$

 D_v^{eff} = the effective vapor diffusion coefficient (m²/sec) $\frac{\Delta C}{\Delta T}$ = the concentration gradient (g/cubic meters per meter [m³m])



The value for D_v^{eff} is specific to Site conditions and the specific gas. The value can be calculated using the equation of Millington and Quirk (1961):

$$D_v^{eff} = D_v^{air} \times \frac{\theta_v^{3.3}}{\theta_T^2}$$

Where:

 D_v^{air} = diffusion coefficient constant in air for oxygen (0.21) or carbon dioxide (0.16) (m²/s)

 θ_{ν} = air-filled porosity

 θ_T = total porosity

Total porosity data are available for several locations at and around the Site and average about 15 percent (Gill and Hubbard, 1985). Air-filled porosity was assumed to be the default USEPA ratio of air filled to the total porosity in the Petroleum Clean-up Level Calculator. 1

The diffusive flux (J) is converted to an NSZD rate using stoichiometric utilization of oxygen or production of carbon dioxide or methane, which for octadecane degradation is obtained from the equation:

$$2C_{18}H_{38} + 55O_2 \rightarrow 36CO_2 + 38H_2O$$

Where the molar masses of the reactants and products are: Octadecane $(C_{18}H_{38})$ = 254.50 g/mol Oxygen (O_2) = 32 g/mol Carbon dioxide (CO_2) = 44.01 g/mol Water (H_2O) = 18.02 g/mol

Which yields utilization ratios of:

- $(2 \times 254.50)/(55 \times 32) = 0.2892$ for oxygen
- $(2 \times 254.50)/(16 \times 44.01) = 0.3213$ for carbon dioxide

Thus, each gram of oxygen that is depleted represents 0.2892 grams of octadecane degraded, each gram of carbon dioxide produced represents 0.3213 grams of octadecane degraded, and each gram of methane equates to 1.1539 grams of octadecane degraded. Values for octadecane depletion measured by oxygen and carbon dioxide reflect the same process (opposite sides of the same chemical reaction); therefore, the values may not be added. Methane was not observed at high enough levels in shallow soil vapor samples to warrant calculating the contribution.

Four, multi-level soil gas monitoring locations were installed at the site during the Phase 2 NSZD Study to facilitate the measurement of vertical subsurface gas profiles (SG-1 through SG-4). SG-1 was located next to well MMX to provide a background monitoring location, whereas the SG-2 through SG-4 were installed adjacent to monitoring wells VW20, VW31, and VW13, respectively. The specific source area locations were selected to be near monitoring wells with high LNAPL thickness near the center of three

¹ https://dec.alaska.gov/applications/spar/webcalc/dsp_scenSelect.asp

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'lobes' of the thickest LNAPL historically observed at the Site. Additional considerations included locations away from active demolition that were safe and accessible to the drilling rig.

Monitoring locations were placed next to existing monitoring wells to facilitate the collection of gas samples immediately above the water table without the risk of installing a gas monitoring point that would periodically flood following groundwater elevation variations. Each location consisted of four discrete boreholes drilled with screened intervals constructed in 4-inch diameter boreholes drilled to the depths indicated in **Table A-2**. Vapor points were constructed of ¼-inch diameter and 6-inch long speed-fit stainless steel screens attached to Teflon tubing fitted with a polypropylene ball valve at the ground surface. Boreholes were backfilled with sand to 2 inches below and 6 inches above the screened interval. A total of 6 inches of dry grout powder was placed above the sand pack to minimize infiltration of water used to hydrate bentonite into the screened interval followed by 18 inches of hydrated bentonite slurry. Grout was then emplaced to the ground surface to minimize potential desiccation cracking from using bentonite slurry to the ground surface. Vapor wells were completed with trafficrated plastic manholes at the ground surface. A schematic of the generalized construction of each of the four locations is shown on **Figure 5-1**.



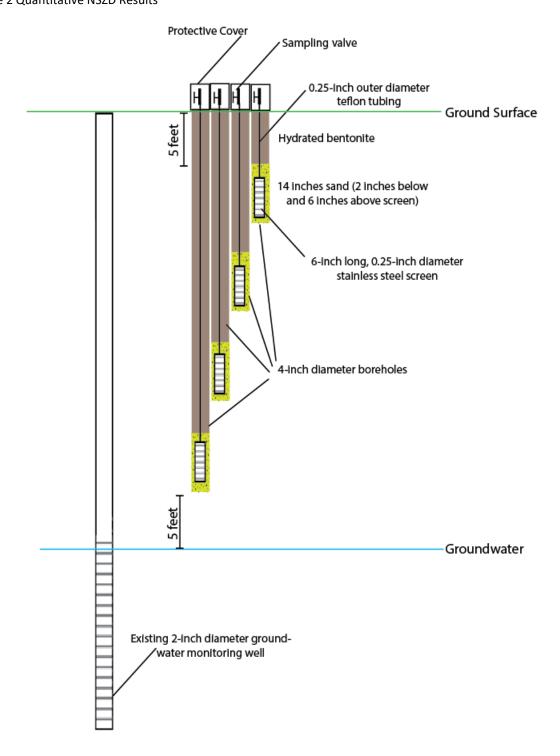


Figure 5-1 Gas gradient well design schematic.

Locations were sampled by purging three times the sand pack volume with an electric pump, followed by measuring headspace gases with a portable multi-gas meter. The deep sample was obtained from the monitoring well at each location as described in **Section 4.2**. A subsequent round of measurements was collected several days later to verify that the vapor wells were not in a state of flux following the



installation. Results of the duplicate sampling rounds are provided on **Table A-2** and indicate that the well readings had stabilized. The first round of readings from soil gas monitoring points coupled with the near-contemporaneous monitoring well headspace readings was used in the gas gradient NSZD calculations.

Measured gas concentration depth profiles (Attachment A3.1) were first corrected to use the water table as a zero datum at each location (Attachment A3.2). Curve fitting to the result in Attachment A3.2 and equations describing each curve were calculated using the R statistical software package 'mgcv' (Wood, 2020). Both linear and GAMs were tested, and the result providing the best fit to the data was used (Attachment A3.3). Data points at 1-foot spacing along the fitted curves were then calculated (Table A-9), and concentration gradients were calculated over the linear portions of the gas concentration profiles. Concentration gradients were corrected for background by subtracting the background (SG-1) gradient from source area (SG-2 through SG-4) gradients. An octadecane density of 0.777 g/mL and standard unit conversion factors were used to calculate the NSZD rate for the Site by using the area of the historical LNAPL extent into three parts represented by source area gas gradient cluster wells SG-2 through SG-4 (Figure A-11).

Detailed calculations for NSZD rates by oxygen depletion and carbon dioxide production are provided in **Table A-10** and **Table A-11**, respectively. The results are summarized in **Table 5-4**.

Table 5-4 Site NSZD Rate Based on Gas Gradient Method

Aqueous NSZD Rates – Gas Gradient Method	NSZD Rate (gallons per year)
Gallons per Year (Oxygen Depletion)	9,507
Gallons per Year (Carbon Dioxide Production)	8,049

NSZD = natural source zone depletion

Gas gradient results using the oxygen depletion and carbon dioxide production methods are similar orders of magnitude, validating the field measurements and calculation procedure. The results confirm multiple additional lines of evidence that NSZD processes are robust at the Site. The magnitude of results is similar to those calculated from the Phase 1 NSZD Study data but is lower than those calculated using other methods employed during the Phase 2 NSZD Study. The lower results are due to a zero NSZD rate calculated for the SG-3 location, which is extrapolated over one-third of the historical LNAPL extent. If results for SG-2 and SG-4 were extrapolated over the historical LNAPL extent, the result would yield rates of 12,074 to 14,261 gallons per year of octadecane degradation. These gas gradient results highlight that calculated NSZD rates are sensitive to the density of data points, and that high resolution and high-density measurements afforded by the DCC technique are the preferred methods for assessing NSZD rates at the Site.

5.4 NSZD Rate Estimate Using Direct Flux Measurements by DCC

The DCC method relies on the collection of ground-surface gas flux data on a sampling grid across the hydrocarbon affected area. The DCC sampling grid for the Phase 2 NSZD Study is shown on **Figure A-12** and **Figure A-13**. The DCC system used a LI-COR Model LI-7810, which is capable of directly measuring



carbon dioxide and methane flux from the ground over time. The instrument was factory calibrated before use (Attachment A-1).

The instrument uses proprietary software to fit a curve to gas concentration measurements as a function of time using an exponential or linear regression model. The equation for the regression curve is then used by the software to calculate the gas flux over time. Three replicate measurements are measured at each location and the result is averaged. If the regression correlation coefficient (R²) value for a specific measurement is less than 0.90, the result is excluded and not used in the average. The average values of the three triplicate gas flux measurements are then used to calculate natural hydrocarbon mass depletion rates in the unsaturated zone, using the procedure described below. Raw results for triplicate measurements for each DCC location are provided in **Table A-3**.

Each monitoring point is assigned a ground cover type and the gas flux from the maximum, average, and minimum flux from a background location with the corresponding ground cover type is subtracted to determine the minimum, average, and maximum proportion of gas flux due to natural hydrocarbon degradation for each location. Results for average carbon dioxide flux and average methane flux (corrected for background) are contoured and shown on **Figure A-12** and **Figure A-13**, respectively. As indicated on **Figure A-12** and **Figure A-13**, elevated carbon dioxide and methane concentrations coincide with the LNAPL extent measured in March 2022, confirming these gases are associated with natural LNAPL mass loss processes.

The maximum, average, and minimum background-corrected gas flux data is then subtracted from each source area DCC measurement to calculate a minimum, average, and maximum hydrocarbon degradation rate. Thiessen polygons are created within the extent of the maximum historical LNAPL footprint and assigned to each DCC monitoring point, and the cross-sectional area is used to calculate the NSZD rate (Figure A-14).

The following equation is used to calculate the octadecane mass depletion rate based on the octadecane degradation reaction:

For carbon dioxide:

$$C_{18}H_{38} + 27.5O_2 \rightarrow 18CO_2 + 19H_2O$$

$$R_{NSZD} = CO_{2(BC)} \times \frac{1 \, mol \, C_{18}H_{38}}{18 \, mol \, CO_2} \times \frac{254.5 \, \frac{g}{mol} \, C_{18}H_{38}}{1 \, mol \, C_{18}H_{38}} \times \frac{86,400 \, sec}{1 \, day} \times \frac{365 \, day}{1 \, year} \times \frac{1 \, mol}{10^6 \, \mu mol} \times P_a$$

Where:

 R_{NSZD} = NSZD Rate (grams octadecane per polygon per year)

 $CO_{2(BC)}$ = Background corrected carbon dioxide flux (micromole per square meter per second [μ mol/m²/sec])

 P_a = Polygon area (m²)

For methane:

$$4C_8H_{18} + 34H_2O \rightarrow 17CO_2 + 55CH_4$$

Appendix A: Detailed Phase 2 Natural Source Zone Depletion Calculations and Results – St. Croix, U.S. Virgin Islands
Phase 2 Quantitative NSZD Results



$$R_{NSZD} = CH_{4(BC)} \times \frac{4 \ mol \ C_{18}H_{38}}{55 \ mol \ CO_2} \times \frac{254.5 \frac{g}{mol} \ C_{18}H_{38}}{1 \ mol \ C_{18}H_{38}} \times \frac{86,400 \ sec}{1 \ day} \times \frac{365 \ day}{1 \ year} \times \frac{1 \ mol}{10^9 \ \mu mol} \times P_a$$

Where:

 $CH_{4(BC)}$ = Background corrected methane flux (nanomole [nmol]/m²/s)

The result for R_{NSZD} is converted to gallons per year by multiplying by the density of octadecane (0.777 grams per mL), and then multiplying by 0.000264172 mL per gallon.

The total mass loss is the sum of the background-corrected carbon dioxide for each polygon plus the sum of background-corrected methane flux. Methane flux is added to the carbon dioxide flux because this represents methane that was not degraded in the subsurface to carbon dioxide. Where the equation results in a negative flux, a value of zero is used. Note, where more than one value was determined for a particular location, the average NSZD rate is used in the sum. As described in **Section 5.4.1**, the linear method used by the LI-COR Software produced better repetition; therefore, results were calculated based on gas flux data for the linear interpolation method. Calculation results are provided in **Table A-12** and summarized on **Figure A-15**.

A summary of calculated mass depletion rates is provided in Table 5-5.

Table 5-5 Site NSZD Rate Based on DCC Measurements

Aqueous NSZD Rates – Groundwater Temperature	Upper-End NSZD Rate	Mean NSZD Rate	Lower-End NSZD Rate
Gallons per year (carbon dioxide flux)	47,914	36,903	24,831
Gallons per year (methane flux)	14	7	3
Total Gallons Per Year	47,928	36,910	24,834

DCC = dynamic closed chamber

NSZD = natural source zone depletion

5.4.1 DCC Quality Control Measures

A collar with a sealed bottom cap was used to measure a field blank to determine the limit of detection. The collar was sealed using a dedicated 8-inch diameter expanding well cap. The chamber was set upon the sealed collar in the field and allowed to record a total of 60 measurements. The results of the field blank were then averaged, and three times the standard deviation of the measurements was added to the average to determine the limit of detection. Tabulated results of the blank measurements and detection limit calculation are provided in **Attachment 4**. Raw measurement results are shown in a box and whisker plot on **Figure 5-2**. As indicated on **Figure 5-2**, several measurements of the blank methane and carbon dioxide flux using an exponential fit resulted in outlier values, thus, these values are excluded from the limit of detection calculation. Based on the stability of the linear methane and carbon dioxide flux determinations in the blank samples, data from the linear gas flux determinations were used to calculate hydrocarbon degradation rates.



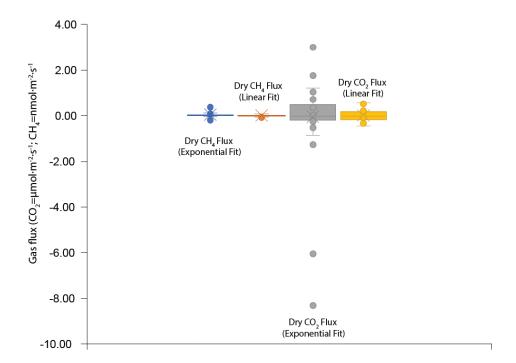


Figure 5-2 Raw blank DCC flux measurements (60 replicates).

No background values for asphalt were available. To conservatively correct for background flux at the two asphalt locations (DCC-VW15 and DCC-25), the most elevated group of background locations (cleared scrub) were used for the background correction.

Eleven duplicate samples were collected for carbon dioxide and methane flux (22 measurements total). Duplicate samples were collected within several minutes of each other to ensure consistent conditions were monitored. All methane and carbon dioxide flux measurements except one were within a relative RPD of 35 percent, the nominal acceptance range for duplicate DCC measurements (CRC CARE, 2015). One measurement for carbon dioxide flux in the primary sample from VW24 was non-detect for carbon dioxide. Duplicate sample statistics are provided in **Attachment 5**.

Multiple DCC measurements were made at some locations at different times and on different days to evaluate temporal stability in measurements. These measurements differed from duplicate samples in that they were not collected sequentially at approximately the same time; there was a deliberate time gap between measurements. Temporal replicate sample data and plots are provided in **Attachment 6**. At St. Croix, annual temperature variations are typically in a narrow range between 73 and 88 degrees Fahrenheit, and tidal fluctuations are small; therefore, the stable tropical climate at the Site is unlikely to lead to substantial temporal variations in the NSZD rate, as demonstrated by temperature gradient NSZD rates determined during both the Phase 1 and Phase 2 NSZD Studies that are the same order of magnitude.

Appendix A: Detailed Phase 2 Natural Source Zone Depletion Calculations and Results – St. Croix, U.S. Virgin Islands
Phase 2 Quantitative NSZD Results



5.5 Summary of Quantitative Results

Quantitative NSZD rate calculations confirm the qualitative evidence that active, robust NSZD is occurring at the Site. LNAPL recovery at the Site from 2016 through 2021 (normalized to an annual rate) was 1,983.6 gallons/year. Total unsaturated zone NSZD rates based on high-resolution DCC measurements range from 24,834 to 47,928 gallons per year across the LNAPL affected area at the Site. The rate is likely slightly higher if aqueous-phase NSZD processes are considered, which were demonstrated to be active at the Site during the Phase 1 NSZD Study.

The NSZD rates based on DCC measurements are higher than estimated using temperature gradient and gas gradient methods (**Table 5-6**). The discrepancy is attributed to the following:

- Temperature and gas gradient approaches are highly sensitive to the height difference between sequential vertical measurements. A shorter vertical distance between measurements results in higher estimated NSZD rates. Given the large vertical spacing between temperature and gas gradient measurements, the results provide a minimum rate estimate as zones of peak or lowest temperature/ gas concentration may have fallen between sampled intervals.
- Horizontal spatial resolution is lower (sparse) compared to DCC measurements. This leads to a
 disproportionately large influence of non-detect/background Thiessen polygons on the overall
 calculated NSZD rate.
- Temperature and gas gradient methods rely on the use of non-Site-specific data and parameters, however, the DCC method does not.

Furthermore, it is critical to consider the calculation methods employed only consider mass transfers in the vertical domain. Vapor and energy (temperature) fluxes also occur horizontally and therefore the methods employed will underestimate mass losses. The higher density of DCC sampling relative to the well-based sampling for temperature and soil gases is likely to better capture both the vertical and lateral fluxes, and this may also account for the differences observed between methods.

NSZD rates calculated from DCC measurements were compared to literature values (all normalized to gallons/acre/year to provide valid comparison) to verify the magnitude of the DCC results is realistic (**Table 5-7**). The DCC results are within the range, but at the low end, of the NSZD rates reported for a diverse range of hydrocarbon sites. Lower rates likely reflect a combination of the chemistry of the LNAPL (middle distillates), its age and weathered state, and the dominant process (methanogenesis) which produces the least energy and therefore is slower relative to other natural degradation processes. This result indicates the DCC results are valid, and further indicates the temperature and gas gradient results are conservative estimates of NSZD rates that are potentially biased low.

The results of the Phase 2 NSZD Study identify that DCC is the preferred method to quantify NSZD rates at the Site, as alternate methods are susceptible to bias from low sampling densities and other factors. Given the high cost of alternative high-resolution NSZD quantification methods, comparable sampling grid densities, as were achieved with the DCC method, cannot be achieved due to prohibitive expense and would likely result in biased NSZD rate estimates. Additionally, the consistent tropical climate and results provided herein demonstrate that NSZD processes are temporally stable.



Table 5-6 Summary of NSZD Rates

Rate	NSZD Rate Attributed to Aqueous (Assimilative Capacity) Reactions	Unsaturated Zone NSZD Rate Based on Sum of Temperature Methods ¹ Gallo	Unsaturated Zone NSZD Rate Based on Gas Gradient Method ² ns per year	NSZD Rate Attributed to Unsaturated Zone (DCC Method) ³
		Phase 1 NSZD Study	-	
Upper-End NSZD Rate	703	8,276		nm
Mean NSZD Rate	508	7,820	nm	nm
Lower-End NSZD Rate	310	7,175		nm
		Phase 2 NSZD Study	У	
Upper-End NSZD Rate	nm	12,747		47,928
Mean NSZD Rate	nm	12,428	8,049 to 9,057*	36,910
Lower-End NSZD Rate	nm	12,003		24,834

¹Sum of differential temperature and groundwater temperature methods.

DCC = dynamic closed chamber

nm = not measured

NSZD = natural source zone depletion

Table 5-7 NSZD Rates at Site Compared to Literature Values

Site Type	Number of Sites	Site-Wide NSZD Rate (Gallons/Acre/Year)
Fuel/diesel/gasoline sites	5	300 to 3,100 ¹
Diverse petroleum sites	11	300 to 5,600 ¹
All studies	25	300 to 700 ¹
St. Croix Alumina DCC maximum	1	564 ²
St. Croix Alumina DCC average	1	434 ²
St. Croix Alumina DCC minimum	1	292 ²

¹ Values sourced from Garg et al. (2017).

DCC = dynamic closed chamber

LNAPL = light non-aqueous phase liquid

NSZD = natural source zone depletion

Garg, S., C.J. Newell, P.R. Kularni, D.C. King, D.T. Adamson, M.I. Renno, and T. Sale. (2017). Overview of Natural Source Zone Depletion: Processes, Controlling Factors, and Composition Change. Groundwater Monitoring & Remediation 37(3), 2017.

² Gas gradient method.

³ Total unsaturated zone NSZD rate for Phase 1 Study is the sum of the groundwater temperature gradient methods. For the Phase 2 Study, this value is the high-resolution DCC measurement.

^{*} = 12,074 to 14,261 gallons per year if SG-3 data is considered to be unrepresentative.

² Site values are calculated assuming the LNAPL affected area is 85 acres.



5.5.1 Use of NSZD Methods to Inform Future Decisions

The following table summarises decision criteria for selection of NSZD assessment methods (Table 5-8).

Table 5-8 Evaluation of NSZD Method Decision Criteria

Method	od Purpose	Decision Criteria	Outcome
High-resolution DCC sampling grid (56 locations)	Determine heterogeneity of NSZD rates across the Site due to surface cover	 Appropriate statistical tests (e.g., t-test comparing different populations) will be used to determine if surface cover and geology contribute to variation in results. Results will inform if subsurface geology and surface cover are necessary criteria in the selection of future sampling locations. Spatial variation will be mapped (and contoured if applicable) to visually determine spatial variability in the results, and if increases or decreases in the DCC sampling density are warranted in future investigations. Locations where appreciable methane flux at the ground surface is detected will be deemed inappropriate for NSZD rate estimation using passive flux chambers. 	 Spatial variation demonstrates the key factor controlling fluxes measured by DCC is the location of LNAPL; ground cover type has limited influence on DCC results (Figure A-12 and Figure A-13), and statistical tests are not warranted. Spatial variations in results indicate that adequate coverage was obtained from the DCC results. Measurements taken on different days and at different times indicate that the flux measured by DCC is stable. This conclusion is verified by temperature gradient and groundwater temperature data that demonstrate robust NSZD has persisted between the Phase 1 and Phase 2 NSZD sampling events. Methane flux was measured at ground surface across the LNAPL affected area. The DCC method provides higher spatial coverage than passive traps at a substantially lower cost and is the preferred method for evaluating NSZD rates at the Site.

Appendix A: Detailed Phase 2 Natural Source Zone Depletion Calculations and Results – St. Croix, U.S. Virgin Islands



anomaly encountered

Study.

during the Phase 1 NSZD

Method	Purpose	Decision Criteria	Outcome
Gas gradient assessment (four multi-level gas gradient well locations [SG-1 through SG-4]). Measurements will be taken at five soil vadose elevations (four if monitoring well screens are submerged).	 Method will be used to verify NSZD rates calculated from DCC data and provide a multiple lines of evidence approach. Gas gradient measurements from SG-1 through SG-4 will be opportunistically obtained during future groundwater monitoring events to verify if temporal changes are apparent. 	 DCC results will be deemed appropriate if results are within one order of magnitude of those from adjacent gas gradient locations. If NSZD rates calculated by DCC are an order of magnitude lower than gas gradient results, DCC results will be deemed biased low, likely due to geologic heterogeneities. If NSZD rates calculated by DCC are over an order of magnitude higher than those calculated by the gas gradient method, potential causes for high bias in DCC results or low bias in gas gradient results will be assessed. 	 DCC results are within an order of magnitude of adjacent gas gradient locations; therefore, DCC results are deemed accurate. Gas gradient results are identified as biased low, due to spacing between screen intervals potentially skipping gas concentration maximum or minimums. Additionally, gas gradient locations are limited to three locations across the LNAPL affected area, thus, the spatial resolution is limited compared to the DCC method.
Temperature gradient methods	Down-well temperature data will be collected opportunistically from a subset of source wells (and one upgradient well) during the Phase 2 scope of work and future groundwater monitoring events to assess temporal variability and verify	Temperature plots from different periods will be compared to assess temporal temperature variations.	NSZD rates calculated using downhole temperature data during the Phase 1 and Phase 2 Studies are within an order of magnitude and demonstrate that NSZD processes are robust and not due to an anomaly approximate and not anomaly approximate.

DCC = dynamic closed chamber LNAPL = light non-aqueous phase liquid NSZD = natural source zone depletion

calculated rates.

Phase 2 Quantitative NSZD Results

Appendix A: Detailed Phase 2 Natural Source Zone Depletion Calculations and Results – St. Croix, U.S. Virgin Islands
Key Study Question Outcomes

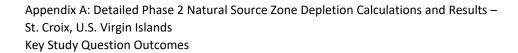


6 Key Study Question Outcomes

Key study questions were developed to guide assessment activities and aid in developing data quality objectives (DQOs). DQOs are presented in the Quality Assurance Project Plan (QAPP) (EHS Support, 2021c). The work tasks and assessment program were developed to address the key questions listed in **Table 6-1**, which were originally provided in the NSZD Workplan (EHS Support, 2021a). The results of the activities described in this Phase 1 NSZD Report and summarized in **Table 6-1** are used to guide additional scopes of work and, ultimately, to prepare the final LNAPL CSM and Management Plan.

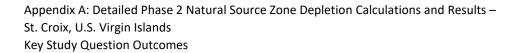
Table 6-1 Key Investigation Question Outcomes

Topic	Key Investigation Questions to Answer as Part of NSZD/MNA Assessment Activities	Question Outcomes Based on Phase 1 and Phase 2 NSZD Studies
Soil Gas Flux Assessment	1. Are soil gas locations representative of the geological and hydrological Site conditions? If not, is further assessment and evaluation warranted? 2. If statistically significant differences in gas concentrations at multiple adjacent wells are identified, additional soil gas monitoring points between monitoring wells may be necessary. 3. Statistically indistinguishable soil gas concentrations between sampling points will provide confidence that geological variations have little effect on soil gas measurements.	1. Surface conditions in the source area include grassy, scrub-covered, and paved areas. DCC sampling locations accounted for all surface cover types and implemented background correction measures. 2. Elevated gas (carbon dioxide and methane) flux measured by DCC in April 2022 coincides with the LNAPL footprint measured in March 2022 (Figure A-12 and Figure A-13). This observation indicates geological variations and surface cover variations place limited controls on NSZD rates and that the primary factor in NSZD rates determined by the DCC method is the location of subsurface LNAPL. 3. As shown in the hydrogeological conceptualization (EHS Support, 2020), the LNAPL extent spans a range of geologic conditions. Correspondence between elevated gas flux and the LNAPL extent indicates geological variations are of limited importance for gas flux measurements.



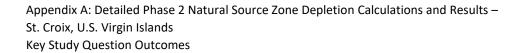


Topic	Key Investigation Questions to Answer as Part of NSZD/MNA Assessment Activities	Question Outcomes Based on Phase 1 and Phase 2 NSZD Studies
	Do groundwater MNA data results indicate that methane sampling is required during subsequent phases? If so, what instrumentation and methods will be used to collect methane (e.g., LI-COR 7810 meter)? If methane is detected above the method detection limit in groundwater samples, then use of a LI-COR meter or installation of soil gas probes will be recommended.	Elevated methane was detected in groundwater samples and well headspace during the Phase 1 and Phase 2 work. Gas flux measured with a LI-COR 7810 meter capable of quantifying carbon dioxide and methane flux confirmed measurable (although low concentrations) of methane at the ground surface that contributed to the calculated NSZD rate.
	Have Site conditions at sample locations (e.g., gravel, concrete) affected the gas readings (carbon dioxide, etc.), requiring additional evaluation (e.g., probe sampling)? If there is a correlation between well headspace gas concentrations and cemented areas, then installation of soil gas probes may be recommended in cemented areas as they will be inaccessible to DCC or passive trap methods.	One background and three source area multi-level soil vapor probe clusters were installed to verify NSZD rates calculated by the DCC method.
	Have Site hydrogeologic conditions (e.g., limestone, perched groundwater) affected soil gas flux results and, if so, to what extent? What supplementary methods have been applied to existing data results and is further assessment required? If cation/anion fingerprinting results from GM-22 and Site wells indicate variable groundwater conditions at the Site, then soil gas flux spatial variability will be assessed.	A groundwater geochemistry assessment completed as part of the Phase 1 work indicated that source groundwater arrives from the upgradient direction, and a seawater mixing zone is present downgradient of the source zone and adjacent to the shoreline. Complexities in groundwater flow are not expected. GM-22 is the only location with variable groundwater, due to its location in a former bauxite residue pond. Therefore, spatial variability in groundwater composition is not a metric that will drive the selection of sampling locations.





Topic	Key Investigation Questions to Answer as Part of NSZD/MNA Assessment Activities	Question Outcomes Based on Phase 1 and Phase 2 NSZD Studies
Groundwater MNA Assessment	Have the monitoring wells selected for MNA analyses adequately met DQOs, and are MNA analyses representative of the potential range of NSZD rates at the Site? If DQOs are not met, then an additional round of sampling or additional lines of evidence for NSZD may be proposed.	MNA analyses are representative of expected aqueous NSZD rates. Groundwater MNA data is considered representative of background and source areas, and additional rounds of measurements are not recommended at this time.
	Do monitoring well locations include a minimum of one well in upgradient (background, clean) source and dissolved phase impacted downgradient areas? If data indicate the background well(s) do not adequately reflect upgradient groundwater conditions, then an aqueous NSZD rate calculation may not be possible.	Adequate background monitoring wells were identified. A valid aqueous NSZD rate was calculated that met the QA/QC criteria proposed in the Work Plan (EHS Support 2021a) during the Phase 1 work.
	Have standard and appropriate practices been followed for groundwater sampling? If groundwater data fail QA/QC criteria contained within the revised QAPP, then the data will not be used to calculate an aqueous NSZD rate.	Groundwater samples were collected during Phase 1 works according to the Work Plan (EHS Support 2021a) and data was assessed per the QAPP. No results were rejected.
	Have monitoring wells screened solely across the stratigraphy where the NAPL smear zone exists, and wells demonstrated to provide representative water quality, been used to avoid bias in the analysis? If representative data for calculating NSZD rates is not available, then results for NSZD rate(s) will be flagged as having a high or low bias.	As outlined in the Work Plan, wells with submerged screens were avoided during the Phase 1 work. No bias flag is recommended based on screen intervals.





Topic	Key Investigation Questions to Answer as Part of NSZD/MNA Assessment Activities	Question Outcomes Based on Phase 1 and Phase 2 NSZD Studies
	Have seasonal changes in the groundwater table and quality been assessed to determine if multiple rounds of data collection are necessary? If data indicate substantial seasonal variability in the water table elevation, then an additional round of data collection may be proposed.	Seasonal changes were evaluated by looking at the historical range of groundwater elevations in each well and were documented in Table 1 of the Phase 1 NSZD report (EHS Support, 2021b). Variability was shown to be minimal. Large variations in groundwater chemistry due to seasonality are not expected.
Overall NSZD Evaluation (Geochemistry and Stoichiometry)	Has the hydrogeochemistry been assessed and have the primary mass transfer processes been determined? Have sufficient measures been performed to estimate the phase transfers (i.e., non-advection contributions)? If study results are inconsistent with the Site CSM, an update to the CSM will be proposed.	The primary mass loss process is determined to be methane oxidation in the unsaturated zone. Sulfate reduction is a supplemental process. The primary aqueous mass loss processes are methanogenesis and sulfate reduction. NSZD processes are understood and accounted for.
	Is the magnitude of the results intuitive and consistent with expectations, published literature, and/or known Site conditions? If results for calculated NSZD rates are inconsistent with literature values, then underlying assumptions about key parameters and hydrogeologic conceptualizations will be revised.	The magnitude of NSZD rates calculated using temperature and gas gradient methods during the Phase 1 and Phase 2 work are lower than the published values (Garg et al., 2017). It is understood that the low bias is due to a combination of factors, including: incomplete oxidation of methane in the subsurface, and vertical and horizontal spacing of temperature and gas gradient measurements resulting in low bias. NSZD rates calculated based on DCC measurements during the Phase 2 work are squarely within the published range of NSZD rates at hydrocarbon sites (Garg et al., 2017).
	Has spatial variability been adequately explained? If the cause of spatial variability is inconclusive, additional data collection may be proposed.	Spatial variability is consistent with the known location of the LNAPL footprint, thus, it is adequately explained.

CSM = Conceptual Site Model
DCC = dynamic closed chamber
DQO = data quality objective
LNAPL = light non-aqueous phase liquid

Appendix A: Detailed Phase 2 Natural Source Zone Depletion Calculations and Results – St. Croix, U.S. Virgin Islands Key Study Question Outcomes



MNA = monitored natural attenuation NAPL = non-aqueous phase liquid NSZD = natural source zone depletion QA = quality assurance QAPP = Quality Assurance Project Plan QC = quality control

EHS Support. 2020. LNAPL CSM and Remedial Action Work Plan. St. Croix Alumina Site, St. Croix, U. S. Virgin Islands. July. EHS Support. (2021b). Phase 1 Natural Source Zone Depletion Assessment Report. St. Croix Alumina Site, St. Croix, U. S. Virgin Islands. December.

Garg, S., C.J. Newell, P.R. Kularni, D.C. King, D.T. Adamson, M.I. Renno, and T. Sale. (2017). Overview of Natural Source Zone Depletion: Processes, Controlling Factors, and Composition Change. Groundwater Monitoring & Remediation 37(3), 2017.

Appendix A: Detailed Phase 2 Natural Source Zone Depletion Calculations and Results – St. Croix, U.S. Virgin Islands
Findings and Recommendations



7 Findings and Recommendations

Findings and recommendations of this Phase 2 NSZD study include:

- 1. The temperature and soil gas data confirm active, robust NSZD is occurring at the Site. However, NSZD rates calculated using these methods are biased low at the Site.
- 2. Methane and hydrogen sulfide gas detections in monitoring wells confirm that LNAPL degradation is occurring via sulfate reduction and methanogenesis.
- 3. Areas of highest methane and carbon dioxide flux measured at the ground surface using the DCC method correspond with the current extent of LNAPL that is greater than 0.2 feet thick.
- 4. Replicate DCC measurements at the same locations on different days and at different times showed only small variations in gas flux. Mass depletion rates calculated using the temperature gradient and groundwater temperature methods during the Phase 1 and Phase 2 NSZD studies were a similar order of magnitude. These results indicate mass depletion rates are stable with time.
- 5. Mass losses determined using high-resolution DCC measurements range between 24,928 gallons and 47,928 gallons per year. These values are consistent with NSZD rates for LNAPL-affected sites elsewhere that are reported in peer-reviewed publications. NSZD rates currently exceed LNAPL recovery rates (3,167 gallons of LNAPL recovered in the last 12 months through May 31, 2022; Attachment B).



8 References

- Arola, T., L. Eskola, J. Hellen, and K. Korkka-Niemi. (2014). Mapping the low enthalpy geothermal potential of shallow Quaternary aquifers in Finland. Geothermal Energy, 2(1), pp.1-20.
- CRC CARE. (2015). A practitioner's guide for the analysis, management and remediation of LNAPL. CRC CARE Technical Report 34. Adelaide, Australia: CRC for Contamination Assessment and Remediation of the Environment.
- CRC CARE. (2018). Technical measurement guidance for LNAPL natural source zone depletion. CRC CARE Technical Report 44. Adelaide, Australia: CRC for Contamination Assessment and Remediation of the Environment.
- EHS Support. (2020). LNAPL CSM and Remedial Action Work Plan. St. Croix Alumina Site, St. Croix, U. S. Virgin Islands. July.
- EHS Support. (2021a). LNAPL Natural Source Zone Depletion Work Plan. St. Croix Alumina Site, St. Croix, U. S. Virgin Islands. April.
- EHS Support. (2021b). Phase 1 Natural Source Zone Depletion Assessment Report. St. Croix Alumina Site, St. Croix, U. S. Virgin Islands. December.
- EHS Support. (2021c). LNAPL Natural Source Zone Depletion Quality Assurance Project Plan (QAPP). St. Croix Alumina Site, St. Croix, U. S. Virgin Islands. June.
- Garg, S., C.J. Newell, P.R. Kularni, D.C. King, D.T. Adamson, M.I. Renno, and T. Sale. (2017). Overview of Natural Source Zone Depletion: Processes, Controlling Factors, and Composition Change. Groundwater Monitoring & Remediation 37(3), 2017.
- GES. (2017). Aquifer Testing and PSH Plume Recoverability/Stability at the Former St. Croix Alumina Site. Prepared for Administrative Order on Consent Docket No. RCRA 02-2001-7301, St. Croix, U.S. Virgin Islands. July 25.
- Gill, I. and D.K. Hubbard. (1985). Subsurface sedimentology of the Miocene-Pliocene Kingshill Limestone, St. Croix, U.S. Virgin Islands.
- GMS. (2020). Site Safety Plan for Groundwater Monitoring and O&M at St. Croix Alumina: 1 Estate Anguilla, Kingshill, St. Croix. October 28.
- Herez, A., M. Khaled, R. Murr, A. Haddad, H. Elhage, and M. Ramadan. (2017). Using geothermal energy for cooling-parametric study. Energy Procedia, 119, pp.783-791.
- ITRC. (2009). Evaluating natural source zone depletion at sites with LNAPL. Interstate Technology and Regulatory Council, LNAPLs Team. http://www.itrcweb.org/GuidanceDocuments/LNAPL-1.pdf

Appendix A: Detailed Phase 2 Natural Source Zone Depletion Calculations and Results – St. Croix, U.S. Virgin Islands
References



- ITRC. (2018). Light non-aqueous phase liquids (LNAPL) document update, LNAPL-3, Interstates Technology and Regulatory Council, LNAPL Update Team, Washington, USA.
- Millington, R.J. and J.P. Quirk. 1961. Permeability of porous solids. Transactions of the Faraday Society, 57, pp.1200-1207.
- Newell, C., T. Sale, J. Connor, P. Kulkarni, and K. Piontek. (2016). Advances in Monitoring Petroleum-Contaminated Sites. Presentation to Federal Remediation Technologies Roundtable (FRTR), November 2.
- Suthersan, S., B. Koons, and M. Schnobrich. (2015). Contemporary Management of Sites with Petroleum LNAPL Presence. Groundwater Monitoring & Remediation 35, 2015.
- Sweeney, R.E. and G.T. Ririe. (2014). Temperature as a Tool to Evaluate Aerobic Biodegradation in Hydrocarbon Contaminated Soil. Groundwater Monitoring & Remediation 34(3), 2014.
- Sweeney, R.E. and G.T. Ririe. (2017). Small purge method to sample vapor from groundwater monitoring wells screened across the water table. Groundwater Monitoring & Remediation, 37(4), pp.51-59.
- Thomas Jr, J., R.R. Frost, and R.D. Harvey. (1973). Thermal conductivity of carbonate rocks. Engineering Geology, 7(1), pp.3-12.
- USEPA. (2009). Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance. EPA-530-R-09-007.
- Warren, E., and B.A. Bekins. (2015). Relating Subsurface Temperature Changes to Microbial Activity at a Crude Oil-Contaminated Site. Journal of Contaminant Hydrology, 182, 2015.
- Wood, S.N. (2020). Inference and computation with generalized additive models and their extensions. Test, 29(2), pp.307-339.



Tables

Monitoring Well Measurements - April 2022 Draft Phase 2 Natural Source Zone Depletion Assessment Report St. Croix Alumina Site St. Croix, U.S. Virgin Islands



Monitoring Well Measurements

St. Croix Alumina

	Well G	auging				Well Headsp	ace Readings		31. 0101	x Alumina				Te	emperature Profil	es		
Well ID	Denth to Eirst	Depth to		2 feet Below	Top of Casing		J	1 foot above	Groundwater		2 feet BGS (°C)	1/4 to Water Table (°C)	Halfway to Water Table (°C)	3/4 to Water	1 foot above groundwater (°C)	1 foot below	5 feet below groundwater (°C)	10 feet below groundwater (°C)
			CH ₄ (% Vol)	CO ₂ (% Vol)	H ₂ S (ppm)	O ₂ (% Vol)	CH ₄ (% Vol)	CO ₂ (% Vol)	H ₂ S (ppm)	O ₂ (% Vol)								
Upgradient W	/ells																	
ММХ	62.64	62.64	1	0.5	0.0		0	10.8	0.0		34.1	33.9	33.7	33.5	33.4	28.4	28.2	28.1
ММ9	81.26	81.26	0	1.2	0.0		0	1.02	0.0		31.8	31.5	30.9	30.4	30	27.8	27.6	27.4
VW3	75.45	75.45	1	0.2	0.0		1	1.6	0.0		25.7	26.9	27.8	28	28	27.8	27.7	27.7
VW8	57.75	57.75	1	1.7	0.0		1	3	0.0		25.5	26.2	26.7	27.1	27.3	27.2	27.1	27.1
VW9R	78.28	78.28	1	0.1	0.0		0	0.6	0.0		25.5	26.4	27.2	27.5	27.7	27.3	27.2	27.2
VW10	88.56	88.56	1	0.4	0.0		0	0.4	0.0		26	27	27.5	27.7	27.8	27.5	27.4	27.4
VW11	72.08	72.08	0	0.1	0.0		1	0.3	0.0		25.8	26.8	27.4	27.8	28	27.9	27.8	27.8

Table A-1 Monitoring Well Measurements - April 2022 Draft Phase 2 Natural Source Zone Depletion Assessment Report St. Croix Alumina Site St. Croix, U.S. Virgin Islands

	Well G	auging				Well Headsp	ace Readings							Te	emperature Profil	es		
Well ID	Depth to First Fluid (feet)			2 feet Below	Top of Casing			1 foot above	Groundwater		2 feet BGS (°C)	1/4 to Water Table (°C)	Halfway to Water Table (°C)	3/4 to Water Table (°C)	1 foot above groundwater (°C)	1 foot below groundwater (°C)	5 feet below groundwater (°C)	10 feet below groundwater (°C)
		(icct)	CH ₄ (% Vol)	CO ₂ (% Vol)	H ₂ S (ppm)	O ₂ (% Vol)	CH ₄ (% Vol)	CO ₂ (% Vol)	H ₂ S (ppm)	O ₂ (% Vol)			()		()			
Source Area V	Wells					l	I		I			l	l					
VW2	41.56	42.05	3.0	15.9	0.0		20.0	17.1	0.0		29.2	29.6	29.8	30.1	30.3	30.2	30.1	30.0
VW5	37.79	38.16	10.0	14.6	0.0		63.0	18.0	0.0		24.5	25.4	26.3	27.2	28.2	29.0	29.4	29.4
VW6	28.02	28.45	1.0	0.1	0.0		6.0	12.2	0.0		27.8	28.4	28.9	29.4	29.5	29.6	29.6	29.6
VW13	30.52	30.90	1.0	0.3	0.0	20.9	27.0	19.0	18.0	0.0	29.4	29.6	29.5	30.3	30.8	31.0	30.9	30.8
VW13B	31.53	31.92	2.0	0.7	0.0	20.6	10.0	14.5	7.0	0.4	28.6	28.5	29.1	29.7	30.4	30.8	30.8	30.7
VW14	33.26	33.88	4.0	12.4	0.0		7.0	16.7	0.0		27.3	27.9	28.5	29.0	29.7	29.8	29.7	29.6
VW20	37.50	37.80	2.0	0.8	5.5	20.9	25.0	11.7	3.0	4.1	27.4	28.1	28.6	29.6	30.8	31.1	31.1	30.9
VW20B	38.02	38.03	1.0	6.7	1.0	11.3	2.0	17.0	4.0	0.0	30.1	30.0	30.0	30.7	31.2	31.3	31.1	30.7
VW21B	37.30	37.68	0.0	10.8	0.0		0.0	17.7	0.0		27.7	28.0	28.5	29.0	29.6	30.2	30.2	29.9
VW23	29.67	29.68	1.0	0.3	0.0		47.0	16.9	19.5		27.8	28.4	29.0	29.5	30.3	30.7	30.6	30.6
VW24	67.28	67.72	2	0.4	0		4	16.3	0.0		30.1	29.4	29	28.9	29.1	29.1	28.9	28.7
VW29	37.22	37.32	9	15	0.6		36	20.3	>100		27.3	27.9	28.7	29.3	30.3	30.6	30.5	30.4
VW30	38.15	38.75	1	2.1	0		1	17.5	0.0		25.8	26.1	26.5	26.9	28.5	29.1	29.1	29.0
VW31	38.58	38.85	0	0.2	0	20.9	2	0.4	0.0	20.9	28.9	29.2	29.2	29.5	29.9	30.2	30.1	30.1
VW32	39.21	39.42	1	14.3	0		11	17.9	13.5		28.3	28.6	28.9	29.2	29.8	30	29.8	29.7
VW35	57.39	57.4	0	0.1	0		0	17.3	0.0		25.2	25.9	26.5	27	27.7	28.5	28.5	28.5

Monitoring Well Measurements - April 2022 Draft Phase 2 Natural Source Zone Depletion Assessment Report St. Croix Alumina Site

	St. Crt	IX AI	umma	Site
t.	Croix,	U.S.	Virgin	Island

	Well G	auging				Well Headsp	ace Readings							T	emperature Profil	es		
Well ID	Depth to First Fluid (feet)	Depth to Second Fluid (feet)		2 feet Below	Top of Casing			1 foot above	Groundwater		2 feet BGS (°C)	1/4 to Water Table (°C)	Halfway to Water Table (°C)	2/4 to Water	1 foot above groundwater (°C)	1 foot below	5 feet below groundwater (°C)	10 feet below groundwater (°C)
		(*****)	CH ₄ (% Vol)	CO ₂ (% Vol)	H ₂ S (ppm)	O ₂ (% Vol)	CH ₄ (% Vol)	CO ₂ (% Vol)	H ₂ S (ppm)	O ₂ (% Vol)			(-,		()			
Downgradien	it Wells																	
VW4	41.54	41.91	12	5.6	0		43	19.1	0		32.4	32.2	32.0	31.9	31.9	31.7	31.3	31.2
VW7	51.39	51.72	1	1.3	0		4	18.9	0		29	29.3	29.6	29.8	29.9	30	29.7	29.5
VW15	43.6	43.6	6	4.1	0		32	18.2	4.5		29	30.2	31	31.4	31.4	30.9	30.4	30
VW16	30.15	30.15	0	1.3	0		0	1.4	0		31.7	31.6	31.5	31.3	31.1	29.4	29.2	29.2
VW18	36.35	36.93	8	14.9	0		8	15.9	0		28.1	28.5	28.8	29.2	30	30.5	30.6	30.4
VW25	35.83	35.83	1	0.8	0		1	2.9	0		26.5	27	27.3	27.4	27.8	27.9	27.9	27.9
VW27	35.78	35.78	0	0.1	0		0	0.3	0		26.6	27.3	27.7	28.2	28.7	29.3	29.3	29.3
VW34	24.3	24.3	1	0.3	0		1	0.3	0		27.7	28.4	28.3	28.1	28.1	27.8	27.8	27.8

Notes: % Vol = percent by volume

°C = degrees Celsius BGS = below ground surface

CH₄ = methane

CO₂ = carbon dioxide

H₂S = hydrogen sulfide

O₂ = oxygen

ppm = parts per million

Table A-2 Soil Gas Readings Draft Phase 2 Natural Source Zone Depletion Assessment Report St. Croix Alumina Site St. Croix, U.S. Virgin Islands



Soil Vapor Well Measurements St. Croix Alumina

Dat	e:		5/3/2	022			5/5/202	22	
Soil Boring ID	Adjacent Well	CH₄ (% Vol)	CO ₂ (% Vol)	H₂S (ppm)	O ₂ (% Vol)	CH₄ (% Vol)	CO ₂ (% Vol)	H₂S (ppm)	O ₂ (% Vol)
MMX-61.64'		0	10.8	0.0					
SG1-56'		0	4.3	0.0	12.8	0	4.2	0	11.3
SG1-39'	ММХ	1	3.9	0.0	15.8	0	4.1	0	11
SG1-21.5'		1	4.8	0.0	16.9	0	4.6	0	14.7
SG1-7.5'		1	1.7	0.0	19.3	0	1.5	0	17.7

Table A-2 Soil Gas Readings

Draft Phase 2 Natural Source Zone Depletion Assessment Report

St. Croix Alumina Site

Date	e:		5/3/2	022			5/5/202	22	
Soil Boring ID	Adjacent Well	CH₄ (% Vol)	CO ₂ (% Vol)	H₂S (ppm)	O ₂ (% Vol)	CH ₄ (% Vol)	CO ₂ (% Vol)	H₂S (ppm)	O ₂ (% Vol)
VW20-37.5		25	11.7	3.0	4.1				
SG2-30'		0	12.4	0.0	4.1	0	12.8	0	2.2
SG2-22'	VW20	0	7.7	0.0	9.9	0	7.6	0	8.9
SG2-14'		1	1.6	0.0	17.4	0	1.7	0	16.1
SG2-6'		1	0.4	0.0	19.3	0	0.4	0	18.2

Table A-2 Soil Gas Readings

Draft Phase 2 Natural Source Zone Depletion Assessment Report

St. Croix Alumina Site

Date	e:		5/3/2	022			5/5/202	22	
Soil Boring ID	Adjacent Well	CH₄ (% Vol)	CO ₂ (% Vol)	H₂S (ppm)	O ₂ (% Vol)	CH₄ (% Vol)	CO ₂ (% Vol)	H₂S (ppm)	O ₂ (% Vol)
VW31-37.85'		2	0.4	0.0	20.9				
SG3-28'		0	12.0	0.0	1.4	0	12.3	0	0.6
SG3-21'	VW31	0	6.7	0.0	9.5	0	6.7	0	8.4
SG3-13'		0	5.6	0.0	11.0	0	5.5	0	9.9
SG3-6'		0	2.9	0.0	15.2	0	3.0	0	13.9

Soil Gas Readings

Draft Phase 2 Natural Source Zone Depletion Assessment Report

St. Croix Alumina Site

St. Croix, U.S. Virgin Islands

Dat	e:		5/3/2	022			5/5/202	22	
Soil Boring ID	Adjacent Well	CH ₄ (% Vol)	CO ₂ (% Vol)	H₂S (ppm)	O ₂ (% Vol)	CH₄ (% Vol)	CO ₂ (% Vol)	H ₂ S (ppm)	O ₂ (% Vol)
VW13-29.9		27	19.0	18.0	0.0				
SG4-23.5'		1	17.6	0.0	0.0	1	17.8	0	0
SG4-18'	VW13	0	13.3	0.0	2.5	0	13.0	0	1.7
SG4-12'		1	8.4	0.0	10.5	0	8.3	0	7.6
SG4-6'		1	3.2	0.0	18.2	1	3.0	0	16.6

Notes:

% Vol = percent by volume

°C = degrees Celsius

BGS = below ground surface

 CH_4 = methane

 CO_2 = carbon dioxide

H₂S = hydrogen sulfide

 O_2 = oxygen

ppm = parts per million

										Dry CH ₄ Flux	Dry CH ₄ Flux	Dry CH ₄ Flux	Dry CH₄ Flux	Dry CO ₂ Flux	Dry CO ₂ Flux	Dry CO ₂ Flux	Dry CO ₂ Flux
Location	Ground Cover	Date	Start Time	Latitude	Longitude	Dry CH ₄	Dry CO ₂	H₂O	Temperature	(Exponential fit)	(Exponential fit)	(Linear fit)	(Linear fit)	(Exponential fit)	(Exponential fit)	(Linear fit)	(Linear fit)
			Eastern (Local) Time	WGS 1983	WGS 1983	nmol·mol ⁻¹	μmol·mol ⁻¹	mmol·mol ⁻¹	°C	nmol·m ⁻² s ⁻¹	R ²	nmol·m ⁻² s ⁻¹	R ²	μmol·m ⁻² s ⁻¹	R ²	μmol·m ⁻² s ⁻¹	R ²
DCC-VW4	Grass	4/26/2022	08:28:40	17.711330	-64.768400	1943.97	452.25	20.49	31.56	-0.68	0.99	-0.68	0.99	2.57	1.00	2.18	0.99
DCC-VW4	Grass	4/26/2022	08:30:26	17.711330	-64.768400	1944.35	487.95	20.30	31.57	-0.69	0.99	-0.69	0.99	1.14	0.55	1.85	0.94
DCC-VW4	Grass	4/26/2022	08:32:12	17.711330	-64.768400	1945.79	476.10	20.10	31.24	-0.66	0.99	-0.66	0.99	5.46	0.93	2.15	0.92
Average	Grass	4/26/2022	08:28:40	17.711330	-64.768400	1944.70	472.10	20.30	31.46	-0.68		-0.68		4.01		2.06	
Standard Deviation						0.96	18.18	0.20	0.18	0.01		0.01		2.05		0.18	
	1				T	1	T		T	1	•						
DCC-VW4DUP	Grass	4/26/2022	08:34:18	17.711330	-64.768400	1944.38	453.82	20.06	30.81	-0.68	1.00	-0.68	1.00	2.11	0.99	2.03	0.99
DCC-VW4DUP	Grass	4/26/2022	08:36:04	17.711330	-64.768400	1944.87	449.24	19.94	30.71	-0.68	0.99	-0.68	0.99	2.51	1.00	2.12	0.99
DCC-VW4DUP	Grass	4/26/2022	08:37:50	17.711330	-64.768400	1944.07	463.34	20.28	31.48	-0.70	0.99	-0.70	0.99	2.76	0.99	2.09	0.99
Average	Grass	4/26/2022	08:34:18	17.711330	-64.768400	1944.44	455.47	20.09	31.00	-0.69		-0.69		2.46		2.08	
Standard Deviation				17.711330	-64.768400	0.40	7.19	0.17	0.42	0.01		0.01		0.33		0.04	
		1 4/00/			T	101			T	1	1 0				0		1 0
DCC-VW7	Grass	4/26/2022	09:45:36	17.713450	-64.768910	1946.95	443.70	21.63	33.22	-0.38	0.99	-0.38	0.99	1.44	0.99	1.29	0.99
DCC-VW7	Grass	4/26/2022	09:47:22	17.713450	-64.768910	1947.26	443.43	21.68	33.85	-0.41	0.99	-0.41	0.99	1.49	0.98	1.34	0.98
DCC-VW7	Grass	4/26/2022	09:49:08	17.713450	-64.768910	1948.18	442.30	21.22	33.92	-0.43	0.99	-0.43	0.99	1.31	0.99	1.31	0.99
Average	Grass	4/26/2022	09:45:36	17.713450	-64.768910	1947.46	443.14	21.51	33.66	-0.41		-0.41		nd		1.31	
Standard Deviation				17.713450	-64.768910	0.64	0.74	0.25	0.39	0.03		0.03		na		0.03	
		T . / / T			1	l			T	1	T						
DCC-VW2	Grass	4/26/2022	09:55:36	17.712020	-64.768980	1945.68	452.76	21.16	35.03	-0.98	1.00	-0.98	1.00	2.22	0.97	2.23	0.97
DCC-VW2	Grass	4/26/2022	09:57:22	17.712020	-64.768980	1958.95	607.48	21.58	36.38	-1.18	0.97	-1.18	0.97	-1.16	0.19	-1.16	0.19
DCC-VW2	Grass	4/26/2022	09:59:08	17.712020	-64.768980	1946.94	462.66	21.46	36.22	-2.12	0.99	-1.15	0.98	2.62	0.92	2.62	0.92
Average	Grass	4/26/2022	09:55:36	17.712020	-64.768980	1950.53	507.63	21.40	35.88	-1.43		-1.11		2.42		2.43	
Standard Deviation				17.712020	-64.768980	7.33	86.61	0.22	0.74	0.61		0.11		0.28		0.27	
DCC \ 1445	•	1/25/2022	40.04.34	47.744.000	64.760440	4046 77	440.74	24.04	26.05	0.72	1.00	0.72	4.00	2.07	1.00	2.62	
DCC-VW5	Grass	4/26/2022	10:04:21	17.711620	-64.769440	1946.77	449.74	21.91	36.05	-0.72	1.00	-0.72	1.00	3.07	1.00	2.63	0.99
DCC-VW5	Grass	4/26/2022	10:06:07	17.711620	-64.769440	1947.28	453.06	21.67	36.91	-0.77	1.00	-0.77	1.00	2.98	0.99	2.23	0.99
DCC-VW5	Grass	4/26/2022	10:07:53	17.711620	-64.769440	1946.36	448.55	22.08	37.71	-0.72	1.00	-0.72	1.00	2.39	0.99	2.32	0.99
Average	Grass	4/26/2022	10:04:21	17.711620	-64.769440	1946.81	450.45	21.88	36.89	-0.74		-0.74		2.81		2.39	
Standard Deviation				17.711620	-64.769440	0.46	2.34	0.21	0.83	0.03		0.03		0.37		0.21	
DCC 1	Classed South	4/26/2022	10:14:07	17.712740	-64.768690	1947.20	440.92	20.25	24.10	0.61	1.00	0.61	1.00	0.95	0.07	0.95	0.97
DCC-1	Cleared Scrub	4/26/2022	10:14:07 10:15:53	17.712740	-64.768690	1947.20	439.94	20.35	34.19 34.40	-0.61 -0.63	1.00 1.00	-0.61 -0.63	1.00 1.00	1.17	0.97 0.99	1.07	0.97
	Cleared Scrub					1947.09	439.94			-0.65	0.99	-0.65	0.99		0.99	1.07	0.99
DCC-1	Cleared Scrub	4/26/2022 4/26/2022	10:17:39	17.712740 17.712740	-64.768690 - 64.768690	1946.96 1947.08	440.99 440.62	20.39 20.36	34.61 34.40	-0.65 - 0.63	0.99	-0.65 - 0.63	0.99	1.13 nd	0.99	1.10 1.04	0.99
Average Standard Deviation	Cleared Scrub	4/20/2022	10:14:07	17.712740	-64.768690 -64.768690	0.12		0.02	0.21	0.02	+	0.02		+		0.08	+
Standard Deviation				17./12/40	-04.708090	0.12	0.59	0.02	0.21	0.02		0.02		na		0.08	1
DCC-BKG-VW9R	Cleared Scrub	4/26/2022	10:25:42	17.713620	-64.769810	1946.93	442.09	20.69	35.43	-0.64	1.00	-0.64	1.00	1.50	0.99	1.50	0.99
DCC-BKG-VW9R	Cleared Scrub	4/26/2022	10:27:28	17.713620	-64.769810	1946.50	442.09	20.69	36.47	-0.65	0.99	-0.65	0.99	1.50	0.99	1.50	0.99
DCC-BKG-VW9R	Cleared Scrub	4/26/2022	10:29:14	17.713620	-64.769810	1948.28	448.32	20.73	36.46	-0.69	1.00	-0.69	1.00	1.50	0.99	1.46	0.99
Average	Cleared Scrub	4/26/2022	10:25:42	17.713620	-64.769810	1948.28	444.20	20.07	36.12	-0.66	1.00	-0.66	1.00	nd	0.99	1.49	0.55
Standard Deviation	Cleared Scrub	7/ 20/ 2022	10.23.42	17.713620	-64.769810	0.93	3.57	0.04	0.60	0.03		0.03		na		0.02	+
Stanuaru Deviation		1		17./13020	-04.709810	0.93	3.37	0.04	0.00	0.03		0.03		na		0.02	



										Dry CH₄ Flux	Dry CH₄ Flux	Dry CH₄ Flux	Dry CH₄ Flux	Dry CO ₂ Flux	Dry CO ₂ Flux	Dry CO ₂ Flux	Dry CO₂ Flux
Location	Ground Cover	Date	Start Time	Latitude	Longitude	Dry CH ₄	Dry CO ₂	H ₂ O	Temperature	(Exponential fit)	(Exponential fit)	(Linear fit)	(Linear fit)	(Exponential fit)	(Exponential fit)	(Linear fit)	(Linear fit)
DCC-4	Cleared Scrub	4/26/2022	10:34:29	17.712880	-64.770290	1946.90	442.15	21.57	36.53	-0.63	1.00	-0.63	1.00	1.40	0.99	1.27	0.99
DCC-4	Cleared Scrub	4/26/2022	10:36:15	17.712880	-64.770290	1946.30	443.25	21.50	37.22	-0.62	1.00	-0.62	1.00	1.08	0.99	1.08	0.99
DCC-4	Cleared Scrub	4/26/2022	10:38:01	17.712880	-64.770290	1945.85	441.71	21.33	36.53	-0.64	1.00	-0.64	1.00	1.04	0.98	1.04	0.98
Average	Cleared Scrub	4/26/2022	10:34:29	17.712880	-64.770290	1946.35	442.37	21.47	36.76	-0.63		-0.63		nd		1.13	
Standard Deviation				17.712880	-64.770290	0.52	0.79	0.13	0.40	0.01		0.01		na		0.13	
DCC-BKG-1	Cleared Scrub	4/26/2022	10:45:48	17.713280	-64.770620	1945.11	440.47	22.23	36.55	-0.69	1.00	-0.69	1.00	0.94	0.98	0.89	0.98
DCC-BKG-1	Cleared Scrub	4/26/2022	10:47:34	17.713280	-64.770620	1945.56	440.83	21.90	37.45	-0.73	1.00	-0.73	1.00	0.60	0.96	0.60	0.96
DCC-BKG-1	Cleared Scrub	4/26/2022	10:49:21	17.713280	-64.770620	1944.91	441.55	21.75	37.47	-0.72	1.00	-0.72	1.00	0.62	0.94	0.62	0.94
Average	Cleared Scrub	4/26/2022	10:45:48	17.713280	-64.770620	1945.19	440.95	21.96	37.16	-0.72		-0.72		nd		0.70	
Standard Deviation				17.713280	-64.770620	0.33	0.55	0.25	0.53	0.02		0.02		na		0.16	
				,		,			_	T	,		T				
DCC-3	Grass	4/26/2022	10:57:24	17.71234	-64.76991	1944.40	437.94	21.84	37.78	-0.87	1.00	-0.87	1.00	0.63	0.92	0.49	0.94
DCC-3	Grass	4/26/2022	10:59:10	17.71235	-64.76991	1947.48	458.70	22.25	39.49	-0.96	0.99	-0.96	0.99	-44.06	0.14	0.40	0.35
DCC-3	Grass	4/26/2022	11:00:56	17.71234	-64.76991	1945.42	441.93	21.72	39.60	-0.82	1.00	-0.82	1.00	1.26	0.99	1.14	0.99
Average	Grass	4/26/2022	10:57:24	17.712343	-64.769910	1945.76	446.19	21.93	38.96	-0.88		-0.88		nd		0.82	
Standard Deviation				17.71234	-64.76991	1.57	11.02	0.28	1.02	0.07		0.07		na		0.46	
		T T		ı						1	1		1				T
DCC-2	Cleared Scrub	4/26/2022	11:06:59	17.712390	-64.769420	1946.96	443.14	20.91	36.74	-0.47	0.99	-0.47	0.99	0.98	0.98	0.98	0.98
DCC-2	Cleared Scrub	4/26/2022	11:08:45	17.712390	-64.769420	1947.54	442.67	20.90	37.98	-0.77	0.96	-0.36	0.92	1.71	0.87	1.54	0.88
DCC-2	Cleared Scrub	4/26/2022	11:10:31	17.712390	-64.769420	1948.57	445.67	20.59	38.10	-0.31	0.93	-0.31	0.93	2.40	0.89	1.92	0.88
Average	Cleared Scrub	4/26/2022	11:06:59	17.712390	-64.769420	1947.69	443.83	20.80	37.61	-0.51		-0.38		0.98		0.98	
Standard Deviation				17.712390	-64.769420	0.82	1.61	0.19	0.75	0.23		0.08		na		na	
		1 . / / 1		I I					T		T						т
DCC-VW15	Asphalt	4/26/2022	11:17:11	17.711530	-64.770060	1947.70	492.92	19.68	34.78	-0.58	0.99	-0.58	0.99	17.99	1.00	17.99	1.00
DCC-VW15	Asphalt	4/26/2022	11:18:56	17.711530	-64.770060	1947.59	482.96	19.85	35.20	-0.50	0.99	-0.50	0.99	15.89	1.00	15.89	1.00
DCC-VW15	Asphalt	4/26/2022	11:20:42	17.711530	-64.770060	1947.20	499.12	20.00	35.34	-0.74	0.98	-0.74	0.98	23.11	0.97	23.11	0.97
Average	Asphalt	4/26/2022	11:17:11	17.711530	-64.770060	1947.50	491.67	19.84	35.11	-0.61		-0.61		19.00		19.00	
Standard Deviation						0.27	8.15	0.16	0.29	0.12		0.12		3.71		3.71	
DCC-VW19	Cross	4/26/2022	11:26:44	17.711880	-64.770980	1946.76	438.69	20.14	33.43	-0.64	1.00	-0.64	1.00	1 21	0.99	1.30	0.99
	Grass													1.31			-
DCC-VW19 DCC-VW19	Grass	4/26/2022 4/26/2022	11:28:30 11:30:16	17.711880 17.711880	-64.770980 -64.770980	1947.07 1947.13	439.70 439.25	20.20	35.16 35.68	-0.62 -0.66	1.00 1.00	-0.62 -0.66	1.00	1.24 1.30	0.99 0.99	1.17	0.99
<u> </u>	Grass	+								-0.66 - 0.64	1.00	-0.64	1.00		0.99		0.99
Average Standard Deviation	Grass	4/26/2022	11:26:44	17.711880	-64.770980 -64.770980	1946.99 0.20	439.21 0.51	20.16 0.04	34.76 1.17	0.02		0.02		nd		1.26 0.07	+
Standard Deviation				17.711880	-04.770980	0.20	0.31	0.04	1.1/	0.02]	0.02		na		0.07	<u> </u>
DCC-13	Grass	4/26/2022	11:35:02	17.711400	-64.770970	1956.38	487.10	18.87	37.10	-0.17	0.90	-0.17	0.90	16.10	0.90	0.66	0.78
DCC-13	Grass	4/26/2022	11:36:47	17.711400	-64.770970	1969.03	595.57	19.41	38.32	-0.17	0.76	-0.17	0.76	-0.52	0.29	-0.52	0.78
DCC-13	Grass	4/26/2022	11:38:33	17.711400	-64.770970	1965.04	541.18	18.93	37.96	-0.28	0.91	-0.28	0.70	-0.32	0.04	-0.14	0.04
Average	Grass	4/26/2022	11:35:02	17.711400	-64.770970	1963.49	541.28	19.07	37.80	-0.28	5.51	-0.22	0.51	16.10	0.04	nd	0.04
Standard Deviation	5,433	7,20,2022	11.55.02	17.711400	-64.770970	6.47	54.24	0.30	0.63	0.06		0.08		na		na	
Standard Deviation				17.711400	07.770370	0.47	37.27	0.30	0.03	0.00	1	0.00	l	ila	1	110	<u> </u>



										Dry CH₄ Flux	Dry CH₄ Flux	Dry CH₄ Flux	Dry CH ₄ Flux	Dry CO ₂ Flux	Dry CO ₂ Flux	Dry CO₂ Flux	Dry CO ₂ Flux
Location	Ground Cover	Date	Start Time	Latitude	Longitude	Dry CH₄	Dry CO ₂	H₂O	Temperature	(Exponential fit)		(Linear fit)	(Linear fit)	(Exponential fit)	(Exponential fit)	(Linear fit)	(Linear fit)
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DCC-5	Grass	4/26/2022	11:43:57	17.712410	-64.771160	1945.89	435.58	19.73	36.28	-1.15	1.00	-1.15	1.00	0.51	0.87	0.48	0.87
DCC-5	Grass	4/26/2022	11:45:43	17.712410	-64.771160	1946.04	436.62	19.82	37.32	-1.22	1.00	-1.22	1.00	0.56	0.94	0.55	0.94
DCC-5	Grass	4/26/2022	11:47:29	17.712410	-64.771160	1946.31	436.66	19.73	37.75	-1.22	1.00	-1.22	1.00	0.60	0.94	0.60	0.94
Average	Grass	4/26/2022	11:43:57	17.712410	-64.771160	1946.08	436.29	19.76	37.12	-1.20		-1.20		nd		nd	
Standard Deviation				17.712410	-64.771160	0.21	0.61	0.05	0.75	0.04		0.04		na		na	
		T							T		1		Τ				
DCC-BKG-MMX-2	Cleared Scrub	4/26/2022	13:03:21	17.712420	-64.773930	1946.38	437.34	20.12	35.80	-0.91	1.00	-0.91	1.00	0.34	0.83	0.24	0.83
DCC-BKG-MMX-2	Cleared Scrub	4/26/2022	13:05:07	17.712420	-64.773930	1946.99	437.65	20.24	37.24	-0.92	1.00	-0.92	1.00	0.37	0.89	0.33	0.90
DCC-BKG-MMX-2	Cleared Scrub	4/26/2022	13:06:53	17.712420	-64.773930	1947.94	437.39	20.01	37.07	-0.92	1.00	-0.92	1.00	0.63	0.92	0.46	0.93
Average	Cleared Scrub	4/26/2022	13:03:21	17.712420	-64.773930	1947.10	437.46	20.13	36.70	-0.91		-0.91		nd		nd	
Standard Deviation				17.712420	-64.773930	0.79	0.17	0.12	0.79	0.01		0.01		na		na	
DCC-VW4-2	Grass	4/26/2022	13:14:43	17.711350	-64.768390	1947.95	441.61	19.85	36.03	-0.73	1.00	-0.73	1.00	1.41	0.99	1.37	0.99
DCC-VW4-2	Grass	4/26/2022	13:16:29	17.711350	-64.768390	1947.04	443.12	19.97	37.36	-0.70	1.00	-0.70	1.00	1.37	0.99	1.30	0.99
DCC-VW4-2	Grass	4/26/2022	13:18:15	17.711350	-64.768390	1967.83	456.92	20.14	37.68	-5.75	0.65	-0.98	0.97	1.22	0.95	1.22	0.95
Average	Grass	4/26/2022	13:14:43	17.711350	-64.768390	1954.27	447.22	19.99	37.02	-0.72	0.03	-0.80	0.57	nd	0.55	1.30	0.55
Standard Deviation		,,=0,====		17.711350	-64.768390	11.75	8.44	0.14	0.88	0.02		0.15		na		0.08	
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DCC-6	Grass	4/26/2022	13:26:51	17.712240	-64.772150	1947.70	441.92	21.26	38.25	-0.53	0.98	-0.53	0.98	1.02	0.96	0.91	0.96
DCC-6	Grass	4/26/2022	13:28:36	17.712240	-64.772150	1946.63	443.47	21.27	40.27	-0.86	0.99	-0.86	0.99	2.43	0.98	1.72	0.97
DCC-6	Grass	4/26/2022	13:30:22	17.712240	-64.772150	1945.84	447.54	21.53	41.01	-1.46	0.94	-1.46	0.94	3.82	0.93	3.82	0.93
Average	Grass	4/26/2022	13:26:51	17.712240	-64.772150	1946.72	444.31	21.35	39.84	-0.95		-0.95		2.42		2.15	
Standard Deviation				17.712240	-64.772150	0.93	2.90	0.15	1.43	0.47		0.47		1.40		1.50	
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DCC-BKG-2	Grass	4/26/2022	13:38:30	17.712850	-64.772230	1946.46	479.48	20.77	36.44	-1.04	1.00	-1.04	1.00	0.44	0.33	0.44	0.33
DCC-BKG-2	Grass	4/26/2022	13:40:15	17.712850	-64.772230	1947.37	451.79	20.86	37.46	-0.92	1.00	-0.92	1.00	1.76	0.98	1.74	0.98
DCC-BKG-2	Grass	4/26/2022	13:42:01	17.712850	-64.772230	1947.54	448.16	20.82	37.16	-1.07	1.00	-1.07	1.00	1.96	0.98	1.97	0.98
Average	Grass	4/26/2022	13:38:30	17.712850	-64.772230	1947.12	459.81	20.82	37.02	-1.01		-1.01		1.86		1.86	
Standard Deviation				17.712850	-64.772230	0.58	17.13	0.05	0.53	0.08		0.08		0.14		0.16	
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DCC-7	Cleared Scrub	4/26/2022	13:47:40	17.711900	-64.772940	1948.36	440.47	20.96	37.29	-0.63	0.99	-0.63	0.99	1.27	0.99	1.27	0.99
DCC-7	Cleared Scrub	4/26/2022	13:49:26	17.711900	-64.772940	1947.50	441.97	20.86	38.53	-0.68	0.99	-0.68	0.99	2.02	0.99	1.50	0.99
DCC-7	Cleared Scrub	4/26/2022	13:51:12	17.711900	-64.772940	1947.99	442.77	21.21	39.81	-0.66	1.00	-0.66	1.00	1.99	0.99	1.81	0.99
Average	Cleared Scrub	4/26/2022	13:47:40	17.711900	-64.772940	1947.95	441.74	21.01	38.55	-0.66		-0.66		nd		1.53	
Standard Deviation				17.711900	-64.772940	0.43	1.17	0.18	1.26	0.03		0.03		na		0.27	
DCC-8	Cleared Scrub	4/26/2022	14:58:35	17.711850	-64.773620	1948.84	435.51	20.01	33.98	-0.92	1.00	-0.92	1.00	-0.66	0.96	-0.66	0.96
DCC-8	Cleared Scrub	4/26/2022	15:00:21	17.711850	-64.773620	1947.92	433.51	19.94	34.49	-1.10	1.00	-1.10	1.00	-0.72	0.97	-0.72	0.90
DCC-8	Cleared Scrub	4/26/2022	15:02:08	17.711850	-64.773620	1947.76	431.09	19.82	34.38	-1.10	1.00	-1.10	1.00	-0.72	0.97	-0.72	0.97
Average	Cleared Scrub	4/26/2022	14:58:35	17.711850	-64.773620	1948.17	433.09	19.92	34.28	-1.03	2.00	-1.03	2.00	nd	5.57	nd	3.57
Standard Deviation	Cicuica Scius	4,20,2022	14.50.55	17.711850	-64.773620	0.58	2.11	0.10	0.27	0.10		0.10		na		na	
		1							1		1		<u>l</u>			- 100	1
DCC-VW24	Grass	4/26/2022	15:07:22	17.711490	-64.773050	1949.74	434.92	20.36	35.07	-0.70	1.00	-0.70	1.00	-0.02	0.03	-0.02	0.03
DCC-VW24	Grass	4/26/2022	15:09:08	17.711490	-64.773050	1949.77	434.60	20.24	36.03	-0.73	1.00	-0.73	1.00	-0.01	0.01	-0.01	0.01
DCC-VW24	Grass	4/26/2022	15:10:54	17.711490	-64.773050	1949.44	435.81	20.44	37.06	-0.71	1.00	-0.71	1.00	0.17	0.57	0.14	0.57
Average	Grass	4/26/2022	15:07:22	17.711490	-64.773050	1949.65	435.11	20.35	36.05	-0.71		-0.71		nd		nd	
Standard Deviation	<u> </u>			17.711490	-64.773050	0.18	0.63	0.10	0.99	0.01		0.01		na		na	1



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Location	Ground Cover	Data	Start Time	Latituda	Longitudo	D C11	D CO		Tomporatura	Dry CH ₄ Flux	Dry CO ₂ Flux						
Location	Ground Cover	Date	Start Time	Latitude	Longitude	Dry CH ₄	Dry CO ₂	H ₂ O	Temperature	(Exponential fit)	(Exponential fit)	(Linear fit)	(Linear fit)	(Exponential fit)	(Exponential fit)	(Linear fit)	(Linear fit)
DCC-VW35	Grass	4/26/2022	15:15:34	17.711440	-64.773930	1946.20	440.01	21.07	33.62	-1.85	1.00	-1.85	1.00	0.96	0.95	0.96	0.95
DCC-VW35	Grass	4/26/2022	15:17:20	17.711440	-64.773930	1948.96	455.64	21.20	34.00	-1.94	1.00	-1.94	1.00	0.81	0.76	0.81	0.76
DCC-VW35	Grass	4/26/2022	15:19:06	17.711440	-64.773930	1946.42	441.01	21.49	34.18	-1.88	1.00	-1.88	1.00	2.08	0.99	1.71	0.99
Average	Grass	4/26/2022	15:15:34	17.711440	-64.773930	1947.19	445.55	21.25	33.93	-1.89		-1.89		nd		1.34	
Standard Deviation				17.711440	-64.773930	1.54	8.75	0.21	0.28	0.04		0.04		na		0.54	
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DCC-11	Grass	4/26/2022	15:23:45	17.711140	-64.774410	1950.61	441.89	21.59	32.20	-0.68	0.99	-0.68	0.99	2.21	0.99	1.94	0.99
DCC-11	Grass	4/26/2022	15:25:31	17.711140	-64.774410	1950.98	441.22	21.34	32.41	-0.66	0.99	-0.66	0.99	2.25	0.99	1.90	0.99
DCC-11	Grass	4/26/2022	15:27:17	17.711140	-64.774410	1950.45	442.48	21.49	32.49	-0.69	0.99	-0.69	0.99	2.43	0.99	2.01	0.99
Average	Grass	4/26/2022	15:23:45	17.711140	-64.774410	1950.68	441.86	21.47	32.37	-0.67		-0.67		2.30		1.95	
Standard Deviation				17.711140	-64.774410	0.27	0.63	0.13	0.15	0.02		0.02		0.12		0.06	
DCC-VW-32	Grass	4/26/2022	15:33:31	17.710560	-64.775200	1951.15	472.99	22.01	34.38	-0.74	1.00	-0.74	1.00	9.32	1.00	7.87	1.00
DCC-VW-32	Grass	4/26/2022	15:35:17	17.710560	-64.775200	1953.16	502.59	22.19	35.21	-0.74	0.99	-0.74	0.99	14.91	1.00	7.96	0.98
DCC-VW-32	Grass	4/26/2022	15:37:03	17.710560	-64.775200	1951.54	467.97	21.92	35.39	-0.73	0.99	-0.73	0.99	8.73	1.00	7.80	1.00
Average	Grass	4/26/2022	15:33:31	17.710560	-64.775200	1951.95	481.18	22.04	34.99	-0.73		-0.73		10.99		7.88	
Standard Deviation				17.710560	-64.775200	1.07	18.71	0.14	0.54	0.00		0.00		3.41		0.08	<u> </u>
DCC-9	Grass	4/26/2022	15:42:59	17.711480	-64.774670	1953.73	442.70	21.14	34.70	-0.19	0.96	-0.19	0.96	1.92	0.99	1.87	0.99
DCC-9	Grass	4/26/2022	15:44:45	17.711480	-64.774670	1953.86	442.38	21.37	36.35	-0.18	0.95	-0.18	0.95	2.11	0.99	1.92	0.99
DCC-9	Grass	4/26/2022	15:46:31	17.711480	-64.774670	1953.97	442.76	21.50	36.82	-0.18	0.96	-0.18	0.96	1.97	0.99	1.91	0.99
Average	Grass	4/26/2022	15:42:59	17.711480	-64.774670	1953.85	442.61	21.34	35.96	-0.18		-0.18		2.00		1.90	
Standard Deviation				17.711480	-64.774670	0.12	0.20	0.18	1.11	0.01		0.01		0.10		0.03	
		T			1				1	T			1				T
DCC-12	Grass	4/26/2022	15:55:42	17.710960	-64.775360	1953.18	443.87	21.86	36.85	-0.37	0.99	-0.37	0.99	2.01	1.00	2.00	1.00
DCC-12	Grass	4/26/2022	15:57:28	17.710960	-64.775360	1953.42	444.80	21.84	37.00	-0.45	0.99	-0.45	0.99	2.47	0.99	2.47	0.99
DCC-12	Grass	4/26/2022	15:59:14	17.710960	-64.775360	1953.42	443.65	22.02	37.19	-0.39	0.99	-0.39	0.99	2.15	1.00	2.15	1.00
Average	Grass	4/26/2022	15:55:42	17.710960	-64.775360	1953.34	444.11	21.91	37.01	-0.41		-0.41		2.21		2.21	
Standard Deviation				17.710960	-64.775360	0.14	0.61	0.10	0.17	0.04		0.04		0.24		0.24	
DCC 10	C	4/26/2022	16.05.22	17.711500	C4 775 440	1052.40	444.06	22.02	24.45	0.63	0.00	0.63	0.00	2.20	0.00	2.20	0.00
DCC-10	Grass	4/26/2022	16:05:23	17.711560	-64.775410	1952.49	444.06	22.03	34.45	-0.63	0.99	-0.63	0.99	2.29	0.99	2.29	0.99
DCC-10	Grass	4/26/2022	16:07:09	17.711560	-64.775410	1952.23	454.39	21.99	33.89 33.47	-0.71	1.00	-0.71 -0.74	1.00	2.91 2.67	0.99	2.49	0.99
DCC-10	Grass Grass	4/26/2022 4/26/2022	16:08:55	17.711560 17.711560	-64.775410 - 64.775410	1952.32 1952.35	448.97 449.14	22.22 22.08	33.94	-0.74 - 0.69	0.99	-0.74	0.99	2.62	0.99	2.48	0.99
Average Standard Deviation	Grass	4/20/2022	16:05:23	17.711560	-64.775410	0.14	5.17	0.12	0.49	0.06		0.06		0.31		0.19	
Standard Deviation		1		17./11560	-64.775410	0.14	5.17	0.12	0.49	0.06		0.06		0.51		0.19	1
DCC-BKG-3	Grass	4/26/2022	16:14:35	17.711960	-64.775680	1956.73	446.13	21.87	33.54	-0.24	0.98	-0.24	0.98	3.09	1.00	2.71	0.99
DCC-BKG-3	Grass	4/26/2022	16:16:21	17.711960	-64.775680	1957.57	447.01	21.98	34.24	-0.24	0.98	-0.24	0.98	2.66	1.00	2.16	0.99
DCC-BKG-3	Grass	4/26/2022	16:18:07	17.711960	-64.775680	1959.69	444.48	21.69	34.22	-0.25	0.98	-0.25	0.98	2.48	0.99	2.04	0.99
Average	Grass	4/26/2022	16:14:35	17.711960	-64.775680	1958.00	445.87	21.85	34.00	-0.25	0.50	-0.25	0.55	2.74	0.55	2.30	0.55
Standard Deviation	0.033	7, 20, 2022	10.14.00	17.711960	-64.775680	1.53	1.28	0.14	0.40	0.01		0.01		0.31		0.36	
		<u> </u>			1 / 5555				1 27.0				1				1
DCC-VW31	Grass	4/26/2022	16:24:56	17.709740	-64.776240	1959.89	440.75	21.13	33.20	-0.09	0.86	-0.09	0.86	1.88	0.99	1.11	0.96
DCC-VW31	Grass	4/26/2022	16:26:42	17.709740	-64.776240	1960.56	439.86	21.32	33.54	-0.10	0.91	-0.10	0.91	1.48	0.98	1.17	0.98
DCC-VW31	Grass	4/26/2022	16:28:28	17.709740	-64.776240	1960.55	440.72	21.48	33.52	-0.09	0.88	-0.09	0.88	1.82	0.99	1.30	0.98
Average	Grass	4/26/2022	16:24:56	17.709740	-64.776240	1960.33	440.44	21.31	33.42	-0.10		-0.10		nd		1.19	
Standard Deviation				17.709740	-64.776240	0.39	0.51	0.18	0.19	na		na		na		0.10	
										1			1				
DCC-VW4-3	Grass	4/26/2022	16:40:27	17.711340	-64.768400	1958.46	446.50	21.44	31.36	-0.75	1.00	-0.75	1.00	1.70	0.99	1.67	0.99
DCC-VW4-3	Grass	4/26/2022	16:42:13	17.711340	-64.768400	1958.14	447.64	21.55	31.51	-0.75	1.00	-0.75	1.00	1.50	0.97	1.50	0.97
DCC-VW4-3	Grass	4/26/2022	16:43:59	17.711340	-64.768400	1957.69	445.59	21.81	31.65	-0.75	1.00	-0.75	1.00	2.10	0.99	1.88	0.99
Average	Grass	4/26/2022	16:40:27	17.711340	-64.768400	1958.10	446.58	21.60	31.50	-0.75		-0.75		nd		1.68	



Table A-3 DCC Results and Calculations Draft Phase 2 Natural Source Zone Depletion Assessment Report St. Croix Alumina Site

										Dry CH₄ Flux	Dry CH₄ Flux	Dry CH₄ Flux	Dry CH₄ Flux	Dry CO ₂ Flux	Dry CO ₂ Flux	Dry CO₂ Flux	Dry CO ₂ Flux
Location	Ground Cover	Date	Start Time	Latitude	Longitudo	D.m., CII	D CO		Tomporaturo	(Exponential fit)	(Exponential fit)	(Linear fit)	(Linear fit)	(Exponential fit)	(Exponential fit)	(Linear fit)	(Linear fit)
Location	Ground Cover	Date	Start rille	Latitude	Longitude	Dry CH ₄	Dry CO ₂	H ₂ O	Temperature	(Exponential III)	(Exponential III)	(Linear III)	(Linear III)	(Exponential III)	(Exponential III)	(Linear III)	(Linear III)
					T				1	I							
DCC-6-2	Grass	4/27/2022	07:46:44	17.712210	-64.772170	1963.66	380.28	21.18	26.95	-0.59	0.99	-0.59	0.99	1.59	0.98	1.39	0.98
DCC-6-2	Grass	4/27/2022	07:48:30	17.712210	-64.772170	1962.89	377.97	21.41	26.73	-0.56	1.00	-0.56	1.00	1.45	0.99	1.45	0.99
DCC-6-2	Grass	4/27/2022	07:50:16	17.712210	-64.772170	1962.46	376.40	21.52	26.79	-0.59	0.99	-0.59	0.99	1.67	0.98	1.41	0.98
Average	Grass	4/27/2022	07:46:44	17.712210	-64.772170	1963.00	378.22	21.37	26.83	-0.58		-0.58		nd		1.42	
Standard Deviation						0.60	1.95	0.17	0.12	0.02		0.02		na		0.03	
DCC) (14/25		4/27/2022	00.02.44	47.700400	64.776330	4054.20	272.60	24.40	20.50	0.42	0.00	0.42	0.00	4 77	0.00	4.56	0.00
DCC-VW25	Grass	4/27/2022	08:02:44	17.708400	-64.776220	1964.38	372.60	21.48	30.50	-0.12	0.89	-0.12	0.89	1.77	0.99	1.56	0.99
DCC-VW25	Grass	4/27/2022	08:04:30	17.708400	-64.776220	1964.41	373.68	21.57	30.24	-0.16	0.92	-0.16	0.92	2.46	0.99	1.62	0.98
DCC-VW25	Grass	4/27/2022	08:06:16	17.708400	-64.776220	1964.24	372.97	21.37	29.56	-0.11	0.86	-0.11	0.86	2.75	0.96	1.23	0.93
Average	Grass	4/27/2022	08:02:44	17.708400	-64.776220	1964.34	373.08	21.47	30.10	-0.16		-0.16		2.33		1.47	
Standard Deviation				17.708400	-64.776220	0.09	0.55	0.10	0.49	na		na		0.50		0.21	
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DCC-VW28	Grass	4/27/2022	08:16:00	17.710260	-64.774550	1965.47	379.95	22.69	30.74	0.09	0.84	0.07	0.84	1.67	0.99	1.36	0.98
DCC-VW28	Grass	4/27/2022	08:17:46	17.710260	-64.774550	1965.45	378.45	22.85	30.73	0.09	0.80	0.09	0.80	1.48	0.98	1.30	0.98
DCC-VW28	Grass	4/27/2022	08:19:32	17.710260	-64.774550	1965.91	383.19	23.28	31.40	0.08	0.78	0.07	0.78	1.44	0.98	1.30	0.98
Average	Grass	4/27/2022	08:16:00	17.710260	-64.774550	1965.61	380.53	22.94	30.95	na		na		nd		1.32	
Standard Deviation				17.710260	-64.774550	0.26	2.42	0.31	0.39	na		na		na		0.03	[
DCC-VW26	Grass	4/27/2022	08:23:48	17.710200	-64.774670	1965.80	381.98	22.38	31.69	0.04	0.61	0.04	0.61	1.44	0.98	1.22	0.98
DCC-VW26	Grass	4/27/2022	08:25:34	17.710200	-64.774670	1965.52	376.45	21.95	31.30	0.06	0.21	0.02	0.15	1.84	0.98	1.43	0.98
DCC-VW26	Grass	4/27/2022	08:27:20	17.710200	-64.774670	1965.79	380.22	21.82	30.75	0.04	0.33	0.02	0.33	1.40	0.99	1.26	0.99
Average	Grass	4/27/2022	08:23:48	17.710200	-64.774670	1965.70	379.55	22.05	31.25	na		na		nd		1.31	
Standard Deviation				17.710200	-64.774670	0.16	2.83	0.29	0.47	na		na		na		0.11	
DCC-VW38	Grass	4/27/2022	08:32:47	17.710480	-64.774000	1963.75	373.37	21.97	33.38	-0.40	0.98	-0.40	0.98	2.21	0.99	1.92	0.99
DCC-VW38	Grass	4/27/2022	08:34:33	17.710480	-64.774000	1963.98	373.29	21.88	33.95	-0.39	0.99	-0.39	0.99	2.09	0.99	1.88	0.99
DCC-VW38	Grass	4/27/2022	08:36:19	17.710480	-64.774000	1963.77	372.42	21.57	33.98	-0.38	0.99	-0.38	0.99	2.90	0.99	1.87	0.98
Average	Grass	4/27/2022	08:32:47	17.710480	-64.774000	1963.83	373.03	21.81	33.77	-0.39		-0.39		2.40		1.89	
Standard Deviation				17.710480	-64.774000	0.13	0.53	0.21	0.34	0.01		0.01		0.43		0.03	
DCC-20	Grass	4/27/2022	08:41:58	17.710270	-64.773080	1964.73	374.27	21.60	29.88	-0.03	0.43	-0.03	0.44	1.97	0.99	1.78	0.99
DCC-20	Grass	4/27/2022	08:43:44	17.710270	-64.773080	1964.84	374.08	21.79	30.31	-0.04	0.57	-0.04	0.57	1.96	0.99	1.96	0.99
DCC-20	Grass	4/27/2022	08:45:30	17.710270	-64.773080	1964.62	375.23	21.97	30.48	-0.05	0.71	-0.05	0.71	2.42	0.99	2.08	0.99
Average	Grass	4/27/2022	08:41:58	17.710270	-64.773080	1964.73	374.53	21.79	30.22	na		na		2.12		1.94	
Standard Deviation				17.710270	-64.773080	0.11	0.62	0.18	0.31	na		na		0.26		0.16	
					•				•	•							•
DCC-VW21	Grass	4/27/2022	08:51:16	17.710500	-64.773000	1962.11	373.67	21.50	31.99	-0.55	0.98	-0.55	0.98	2.93	0.98	1.96	0.97
DCC-VW21	Grass	4/27/2022	08:53:02	17.710500	-64.773000	1962.06	373.62	21.56	31.92	-0.94	0.99	-0.65	0.98	3.25	0.98	2.00	0.96
DCC-VW21	Grass	4/27/2022	08:54:48	17.710500	-64.773000	1961.76	374.69	21.67	32.11	-0.63	0.99	-0.63	0.99	2.51	0.99	2.02	0.98
Average	Grass	4/27/2022	08:51:16	17.710500	-64.773000	1961.98	373.99	21.58	32.01	-0.71		-0.61		2.89		1.99	
Standard Deviation				17.710500	-64.773000	0.19	0.60	0.08	0.10	0.21		0.06		0.37		0.03	
		L				1					<u>. </u>						•
DCC-29	Grass	4/27/2022	09:00:05	17.710730	-64.772450	1962.91	370.07	21.22	32.75	-0.54	0.99	-0.54	0.99	0.75	0.97	0.75	0.97
DCC-29	Grass	4/27/2022	09:01:50	17.710730	-64.772450	1962.82	370.43	21.41	33.35	-0.54	0.99	-0.54	0.99	0.72	0.96	0.67	0.96
DCC-29	Grass	4/27/2022	09:03:36	17.710730	-64.772450	1963.08	369.31	21.55	33.47	-0.47	0.97	-0.47	0.97	1.29	0.93	0.52	0.86
Average	Grass	4/27/2022	09:00:05	17.710730	-64.772450	1962.93	369.94	21.40	33.19	-0.51		-0.51		nd		0.65	
Standard Deviation	-	. ,		17.710730	-64.772450	0.13	0.57	0.16	0.39	0.04		0.04		na		0.12	
		1				ı		-			<u>ı</u>		1			<u> </u>	1
DCC-21	Gravel	4/27/2022	09:10:21	17.710080	-64.772210	1964.94	369.32	21.06	31.83	-0.05	0.41	-0.03	0.42	0.95	0.98	0.95	0.98
DCC-21	Gravel	4/27/2022	09:12:07	17.710080	-64.772210	1964.81	368.21	21.06	31.06	-0.04	0.51	-0.04	0.51	0.98	0.96	0.88	0.96
DCC-21	Gravel	4/27/2022	09:13:54	17.710080	-64.772210	1964.78	368.39	21.35	31.45	-0.04	0.59	-0.04	0.59	0.96	0.97	0.83	0.97
Average	Gravel	4/27/2022	09:10:21	17.710080	-64.772210	1964.84	368.64	21.16	31.45	na		na		nd		0.89	
Standard Deviation		-,,	-3	17.710080	-64.772210	0.09	0.60	0.17	0.39	na		na		na		0.06	
Standard Deviation				17.710000	04.772210	0.03	0.00	0.1/	0.33	IIa	l l	IIG	<u> </u>	ΠQ	l	0.00	l



										Dry CH ₄ Flux	Dry CH₄ Flux	Dry CH ₄ Flux	Dry CH ₄ Flux	Dry CO ₂ Flux			
Location	Ground Cover	Date	Start Time	Latitude	Longitude	Dry CH ₄	Dry CO ₂	H ₂ O	Temperature	(Exponential fit)	(Exponential fit)	(Linear fit)	(Linear fit)	(Exponential fit)	(Exponential fit)	(Linear fit)	(Linear fit)
DCC-VW20	Grass	4/27/2022	09:30:08	17.711090	-64.772380	1962.70	386.32	23.80	31.25	-0.57	0.99	-0.57	0.99	4.95	1.00	4.86	1.00
DCC-VW20	Grass	4/27/2022	09:31:54	17.711090	-64.772380	1962.41	387.36	23.88	32.50	-0.59	0.99	-0.59	0.99	5.22	1.00	4.72	1.00
DCC-VW20	Grass	4/27/2022	09:33:39	17.711090	-64.772380	1962.29	388.54	23.76	32.93	-0.63	1.00	-0.63	1.00	4.96	1.00	4.70	1.00
Average	Grass	4/27/2022	09:30:08	17.711090	-64.772380	1962.47	387.41	23.82	32.23	-0.59		-0.59		5.05		4.76	
Standard Deviation				17.711090	-64.772380	0.21	1.11	0.06	0.88	0.03		0.03		0.15		0.09	
		1		Γ		1	T	T	1	1							
DCC-VW20DUP	Grass	4/27/2022	09:36:29	17.711090	-64.772380	1964.72	394.46	22.37	32.09	-0.64	0.99	-0.64	0.99	5.44	1.00	4.84	1.00
DCC-VW20DUP	Grass	4/27/2022	09:38:15	17.711090	-64.772380	1962.97	384.86	22.46	32.21	-0.61	0.99	-0.61	0.99	4.78	1.00	4.50	1.00
DCC-VW20DUP	Grass	4/27/2022	09:40:01	17.711090	-64.772380	1962.58	384.10	22.04	31.51	-0.68	1.00	-0.68	1.00	5.59	1.00	5.01	1.00
Average	Grass	4/27/2022	09:36:29	17.711090	-64.772380	1963.42	387.81	22.29	31.94	-0.64		-0.64		5.27		4.78	
Standard Deviation				17.711090	-64.772380	1.14	5.77	0.22	0.37	0.04		0.04		0.43		0.26	-
DCC-14	Gravel	4/27/2022	09:49:06	17.710860	-64.771710	1963.96	367.77	21.05	32.11	-0.19	0.97	-0.19	0.97	0.94	0.97	0.86	0.97
DCC-14	Gravel	4/27/2022	09:50:52	17.710860	-64.771710	1963.69	366.86	21.04	32.15	-0.19	0.95	-0.19	0.95	1.15	0.94	0.89	0.94
DCC-14	Gravel	4/27/2022	09:52:38	17.710860	-64.771710	1963.58	366.64	21.19	32.13	-0.19	0.96	-0.19	0.96	0.81	0.98	0.81	0.98
Average	Gravel	4/27/2022	09:49:06	17.710860	-64.771710	1963.74	367.09	21.09	32.13	-0.19		-0.19		nd		0.85	
Standard Deviation				17.710860	-64.771710	0.19	0.60	0.08	0.02	0.00		0.00		na		0.04	
DCC-VW30	Gravel	4/27/2022	09:59:11	17.711590	-64.771720	1953.88	379.88	21.79	33.98	-2.87	1.00	-2.05	0.99	4.26	0.99	2.54	0.98
DCC-VW30	Gravel	4/27/2022	10:00:57	17.711590	-64.771720	1956.85	371.75	21.25	33.90	-1.68	1.00	-1.68	1.00	2.61	0.99	1.76	0.98
DCC-VW30	Gravel	4/27/2022	10:02:44	17.711590	-64.771720	1956.66	370.92	21.20	33.28	-1.68	0.99	-1.68	0.99	2.33	0.98	1.78	0.98
Average	Gravel	4/27/2022	09:59:11	17.711590	-64.771720	1955.80	374.18	21.41	33.72	-2.08		-1.80		3.06		2.03	
Standard Deviation				17.711590	-64.771720	1.66	4.95	0.33	0.38	0.69		0.21		1.04		0.45	
DCC VIVI19	Crass	4/27/2022	10:00:49	17 710660	64 771120	1062.00	205.72	22.10	21.72	1 21	1.00	1 21	1.00	0.00	1.00	0 11	1.00
DCC-VW18 DCC-VW18	Grass Grass	4/27/2022	10:09:48 10:11:34	17.710660 17.710660	-64.771120 -64.771120	1962.89 1965.09	395.72 392.70	22.10 22.71	31.72 32.23	-1.31 -1.25	1.00 1.00	-1.31 -1.25	1.00 1.00	8.89 7.77	1.00 1.00	7.77	1.00 1.00
DCC-VW18	Grass	4/27/2022	10:13:21	17.710660	-64.771120	1963.32	393.66	22.71	31.98	-1.23	1.00	-1.23	1.00	8.13	1.00	8.13	1.00
Average	Grass	4/27/2022	10:09:48	17.710660	-64.771120	1963.76	394.03	22.27	31.97	-1.28	1.00	-1.28	1.00	8.26	1.00	8.00	1.00
Standard Deviation	0.033	4,2,7,2022	10.031-10	17.710660	-64.771120	1.17	1.54	0.38	0.26	0.03		0.03		0.57		0.20	
							1								I		
DCC-VW18DUP	Grass	4/27/2022	10:16:22	17.710650	-64.771120	1961.26	399.67	21.96	31.44	-1.35	1.00	-1.35	1.00	9.62	1.00	8.26	1.00
DCC-VW18DUP	Grass	4/27/2022	10:18:08	17.710650	-64.771120	1962.86	394.55	23.11	31.72	-1.32	1.00	-1.32	1.00	8.58	1.00	8.14	1.00
DCC-VW18DUP	Grass	4/27/2022	10:19:54	17.710650	-64.771120	1960.94	399.39	21.63	31.38	-1.31	1.00	-1.31	1.00	9.21	1.00	8.19	1.00
Average	Grass	4/27/2022	10:16:22	17.710650	-64.771120	1961.69	397.87	22.23	31.51	-1.33		-1.33		9.14		8.20	
Standard Deviation				17.710650	-64.771120	1.03	2.88	0.78	0.18	0.02		0.02		0.52		0.06	
Т				T	1	1	1	I		T					1		T
DCC-23	Grass	4/27/2022	10:24:57	17.710980	-64.770890	1959.99	371.86	21.22	31.91	-1.25	1.00	-1.25	1.00	2.88	0.99	2.27	0.99
DCC-23	Grass	4/27/2022	10:26:42	17.710980	-64.770890	1960.06	370.68	20.94	32.03	-1.32	1.00	-1.32	1.00	3.22	0.99	2.65	0.99
DCC-23	Grass	4/27/2022	10:28:28	17.710980	-64.770890	1960.14	370.35	21.00	31.84	-1.30	1.00	-1.30	1.00	3.09	0.99	2.53	0.99
Average Standard Doviation	Grass	4/27/2022	10:24:57	17.710980	-64.770890	1960.06	370.96	21.06	31.93	-1.29		-1.29 0.04		3.06 0.17		2.49 0.20	
Standard Deviation				17.710980	-64.770890	0.08	0.79	0.15	0.09	0.04	1	0.04	<u> </u>	0.17		0.20	-
DCC-24	Gravel	4/27/2022	10:32:27	17.710590	-64.770720	1958.91	375.86	21.01	31.85	-1.67	0.99	-1.67	0.99	4.84	0.99	4.29	0.99
DCC-24	Gravel	4/27/2022	10:34:12	17.710590	-64.770720	1959.58	373.39	20.90	31.65	-1.22	0.98	-1.22	0.98	6.12	0.99	3.38	0.96
DCC-24	Gravel	4/27/2022	10:35:58	17.710590	-64.770720	1960.05	371.20	20.84	31.41	-1.97	0.96	-0.94	0.96	5.47	0.99	2.38	0.95
Average	Gravel	4/27/2022	10:32:27	17.710590	-64.770720	1959.51	373.48	20.92	31.64	-1.62		-1.28		5.48		3.35	
Standard Deviation				17.710590	-64.770720	0.58	2.33	0.09	0.22	0.38		0.37		0.64		0.96	
DCC-VW17	Grass	4/27/2022	10:40:36	17.710320	-64.770990	1966.01	366.49	21.64	33.04	-0.17	0.97	-0.17	0.97	1.84	0.99	1.64	0.99
DCC-VW17	Grass	4/27/2022	10:42:22	17.710320	-64.770990	1964.28	365.85	21.04	32.88	-0.20	0.97	-0.20	0.97	1.84	0.99	1.68	0.99
DCC VAV17	Cross	4/27/2022	10.44.00	17 710220	C4 770000	1002 02	200.00	21.17	22.25	0.10	0.00	0.10	0.00	2.10	0.00	1 70	0.00



DCC-VW17

Average

Standard Deviation

Grass

Grass

4/27/2022

4/27/2022

10:44:08

10:40:36

17.710320

17.710320

17.710320

-64.770990

-64.770990

-64.770990

1963.63

1964.64

1.23

366.09

366.14

0.32

21.17

21.28

0.32

32.35

32.75

0.36

-0.19

-0.19

0.02

0.96

-0.19

-0.19

0.02

0.96

2.19

1.96

0.20

0.99

1.70

1.67

0.03

0.98

										Dry CH₄ Flux	Dry CH₄ Flux	Dry CH ₄ Flux	Dry CH ₄ Flux	Dry CO ₂ Flux			
Location	Ground Cover	Date	Start Time	Latitude	Longitude	Dry CH ₄	Dry CO ₂	H ₂ O	Temperature	(Exponential fit)	(Exponential fit)	(Linear fit)	(Linear fit)	(Exponential fit)	(Exponential fit)	(Linear fit)	(Linear fit)
					_	1				T							
DCC-22	Grass	4/27/2022	10:50:10	17.710360	-64.771520	1963.40	361.35	20.42	28.91	-0.57	0.99	-0.57	0.99	-0.24	0.62	-0.24	0.62
DCC-22	Grass	4/27/2022	10:51:56	17.710360	-64.771520	1963.64	360.92	20.44	29.07	-0.62	0.98	-0.62	0.98	-0.41	0.26	-0.05	0.10
DCC-22	Grass	4/27/2022	10:53:42	17.710360	-64.771520	1963.38	360.38	20.78	29.47	-0.65	0.99	-0.65	0.99	-0.24	0.67	-0.24	0.67
Average Standard Dovistion	Grass	4/27/2022	10:50:10	17.710360	- 64.771520 -64.771520	1963.47 0.15	360.88 0.49	20.54 0.20	29.15 0.29	-0.61 0.04		-0.61 0.04		nd		nd	
Standard Deviation				17.710360	-04.771320	0.15	0.49	0.20	0.29	0.04		0.04		na		na	-
DCC-25	Asphalt	4/27/2022	10:58:54	17.710080	-64.770500	1963.39	377.85	20.15	31.49	-0.27	0.98	-0.27	0.98	5.45	1.00	4.40	0.99
DCC-25	Asphalt	4/27/2022	11:00:40	17.710080	-64.770500	1963.40	378.29	20.12	32.05	-0.28	0.99	-0.28	0.99	5.31	1.00	4.50	1.00
DCC-25	Asphalt	4/27/2022	11:02:26	17.710080	-64.770500	1963.49	377.72	20.24	31.87	-0.27	0.99	-0.27	0.99	5.01	1.00	4.46	1.00
Average	Asphalt	4/27/2022	10:58:54	17.710080	-64.770500	1963.43	377.95	20.17	31.80	-0.28		-0.28		5.26		4.45	
Standard Deviation				17.710080	-64.770500	0.05	0.30	0.06	0.29	0.01		0.01		0.23		0.05	
		•		•	•	•	•		•	•	•					•	
DCC-25DUP	Asphalt	4/27/2022	11:04:41	17.710090	-64.770480	1963.48	378.92	20.14	31.72	-0.27	0.98	-0.27	0.98	5.25	1.00	4.70	1.00
DCC-25DUP	Asphalt	4/27/2022	11:06:28	17.710090	-64.770480	1963.43	382.12	20.57	32.95	-0.30	0.98	-0.30	0.98	5.49	1.00	4.86	1.00
DCC-25DUP	Asphalt	4/27/2022	11:08:14	17.710090	-64.770480	1963.34	380.07	20.63	32.23	-0.29	0.98	-0.29	0.98	5.21	1.00	4.93	1.00
Average	Asphalt	4/27/2022	11:04:41	17.710090	-64.770480	1963.41	380.37	20.45	32.30	-0.29		-0.29		5.32		4.83	
Standard Deviation				17.710090	-64.770480	0.07	1.62	0.27	0.62	0.01		0.01		0.15		0.12	
DCC-15	Cleared Scrub	4/27/2022	11:15:42	17.710710	-64.768050	1996.10	366.44	20.06	35.98	-0.71	0.98	-0.71	0.98	0.51	0.90	0.46	0.90
DCC-15	Cleared Scrub	4/27/2022	11:17:28	17.710710	-64.768050	1972.40	366.06	20.00	35.14	-0.71	0.99	-0.71	0.98	0.30	0.78	0.30	0.78
DCC-15	Cleared Scrub	4/27/2022	11:17:28	17.710710	-64.768050	1977.19	369.69	20.25	36.08	-0.59	0.98	-0.59	0.98	1.06	0.94	0.48	0.90
Average	Cleared Scrub	4/27/2022	11:15:42	17.710710	-64.768050	1981.90	367.40	20.17	35.73	-0.58	0.50	-0.58	0.50	nd	0.54	nd	0.50
Standard Deviation		1	<u> </u>	17.710710	-64.768050	12.53	2.00	0.10	0.52	0.13		0.13		na		na	
				1	•				1		•						
DCC-VW6	Grass	4/27/2022	11:26:29	17.711020	-64.769170	2018.05	374.85	20.86	36.22	-0.84	0.30	-0.84	0.30	2.43	0.99	2.10	0.99
DCC-VW6	Grass	4/27/2022	11:28:15	17.711020	-64.769170	1967.23	373.53	20.71	37.14	-0.16	0.80	-0.16	0.80	2.64	0.99	2.23	0.99
DCC-VW6	Grass	4/27/2022	11:30:01	17.711020	-64.769170	1971.94	370.98	20.49	35.03	-0.31	0.97	-0.31	0.97	2.23	0.99	2.23	0.99
Average	Grass	4/27/2022	11:26:29	17.711020	-64.769170	1985.74	373.12	20.68	36.13	na		na		2.43		2.19	
Standard Deviation				17.711020	-64.769170	28.08	1.97	0.19	1.06	na		na		0.20		0.07	
DCC VIVA A	C	4/27/2022	44.25.22	47.744400	64.760000	1062.07	270.00	24.07	26.02	0.00	1.00	0.00	1.00	1.01	0.00	1.01	0.00
DCC-VW14 DCC-VW14	Grass Grass	4/27/2022 4/27/2022	11:35:22 11:37:08	17.711180 17.711180	-64.769800 -64.769800	1962.07 1962.34	370.08 369.35	21.07	36.82 36.67	-0.80 -0.74	1.00	-0.80 -0.74	1.00	1.81 1.83	0.99 0.99	1.81 1.52	0.99
DCC-VW14	Grass	4/27/2022	11:38:54	17.711180	-64.769800	1962.34	370.36	20.81	37.27	-0.74	1.00	-0.72	1.00	1.78	1.00	1.70	0.99
Average	Grass	4/27/2022	11:35:22	17.711180	-64.769800	1962.23	369.93	20.93	36.92	-0.75	1.00	-0.75	1.00	1.81	1.00	1.68	0.55
Standard Deviation		1,27,2022		17.711180	-64.769800	0.14	0.52	0.13	0.31	0.04		0.04		0.03		0.15	
L		1			I		I		L	I.						I	
DCC-VW13	Grass	4/27/2022	11:44:28	17.710390	-64.770080	1965.02	372.05	20.29	35.40	-0.10	0.90	-0.10	0.90	2.74	0.99	2.33	0.99
DCC-VW13	Grass	4/27/2022	11:46:14	17.710390	-64.770080	1964.87	371.17	20.48	36.30	-0.10	0.89	-0.10	0.89	2.49	0.99	2.35	0.99
DCC-VW13	Grass	4/27/2022	11:48:00	17.710390	-64.770080	1964.92	371.98	20.24	35.69	-0.12	0.93	-0.12	0.93	2.57	1.00	2.33	1.00
Average	Grass	4/27/2022	11:44:28	17.710390	-64.770080	1964.94	371.73	20.34	35.80	-0.11		-0.11		2.60		2.33	
Standard Deviation				17.710390	-64.770080	0.08	0.49	0.12	0.46	0.01		0.01		0.13		0.01	
200111100		1/27/2222	40.50.05	17.710.000	T =	4054.45	.==						0.00	2.22			
DCC-VW23	Grass	4/27/2022	12:53:37	17.710420	-64.769480	1964.45	375.63	20.06	36.07	-0.38	0.99	-0.38	0.99	2.33	0.99	1.95	0.99
DCC-VW23 DCC-VW23	Grass Grass	4/27/2022 4/27/2022	12:55:22 12:57:08	17.710420 17.710420	-64.769480 -64.769480	1964.44 1964.29	373.44 374.71	19.64 19.85	35.61 36.87	-0.43 -0.43	0.99 0.99	-0.43 -0.43	0.99 0.99	2.00 2.10	0.99 0.99	2.00 2.10	0.99
Average	Grass	4/27/2022	12:57:08	17.710420	-64.769480 -64.769480	1964.29 1964.39	374.71 374.59	19.85	36.18	-0.43 - 0.41	0.33	-0.43 - 0.41	0.55	2.10 2.14	0.33	2.10	0.33
Standard Deviation	G1033	7/2//2022	12.53.31	17.710420	-64.769480	0.09	1.10	0.21	0.63	0.03		0.03		0.17		0.07	
		1				1 2.00			1	1 2200	1					1	
DCC-16	Cleared Scrub	4/27/2022	13:03:20	17.710440	-64.768800	1979.13	372.55	19.47	35.79	2.28	0.91	1.82	0.91	1.53	0.98	1.10	0.97
DCC-16	Cleared Scrub	4/27/2022	13:05:05	17.710440	-64.768800	1971.10	370.71	19.75	37.00	-0.32	0.88	-0.32	0.88	1.08	0.91	0.59	0.89
DCC-16	Cleared Scrub	4/27/2022	13:06:51	17.710440	-64.768800	1971.68	373.74	19.84	37.68	-0.34	0.89	-0.34	0.89	2.14	0.98	1.23	0.96
Average	Cleared Scrub	4/27/2022	13:03:20	17.710440	-64.768800	1973.97	372.33	19.69	36.82	0.54		0.38		nd		1.16	
Standard Deviation				17 710440	-64 768800	4.48	1.53	0.19	0.95	1.51		1.24		l na		0.10	1



Standard Deviation

17.710440

-64.768800

4.48

1.53

0.19

0.95

1.51

1.24

na

Table A-3 DCC Results and Calculations Draft Phase 2 Natural Source Zone Depletion Assessment Report St. Croix Alumina Site

										Dry CH ₄ Flux	Dry CO ₂ Flux						
Location	Ground Cover	Date	Start Time	Latitude	Longitude	Dry CH ₄	Dry CO ₂	H ₂ O	Temperature	(Exponential fit)	(Exponential fit)	(Linear fit)	(Linear fit)	(Exponential fit)	(Exponential fit)	(Linear fit)	(Linear fit)
DCC-19	Grass	4/27/2022	13:14:49	17.709100	-64.770230	1963.78	372.94	19.65	37.47	-0.50	0.99	-0.50	0.99	1.76	0.99	1.76	0.99
DCC-19	Grass	4/27/2022	13:16:35	17.709100	-64.770230	1970.98	374.20	19.99	38.62	-0.53	0.99	-0.53	0.99	1.68	0.99	1.67	0.99
DCC-19	Grass	4/27/2022	13:18:21	17.709100	-64.770230	1963.96	374.20	19.52	37.38	-0.53	1.00	-0.53	1.00	1.72	0.99	1.63	0.99
Average	Grass	4/27/2022	13:14:49	17.709100	-64.770230	1966.24	370.30 372.70	19.72	37.82	-0.52	1.00	-0.52	1.00	1.72	0.55	1.69	0.55
Standard Deviation	Grass	4,2,7,2022	10:14:43	17.709100	-64.770230	4.10	1.63	0.24	0.69	0.02		0.02		0.04		0.07	
Standard Beviation				17.703100	04.770230	4,10	1.05	0.24	0.03	0.02	1	0.02		0.04		0.07	
DCC-18	Gravel	4/27/2022	13:23:53	17.709400	-64.769390	1966.43	371.65	20.26	36.98	-0.03	0.06	-0.03	0.08	1.47	0.99	1.47	0.99
DCC-18	Gravel	4/27/2022	13:25:39	17.709400	-64.769390	1982.62	370.97	19.90	37.87	-0.92	0.98	-0.52	0.97	1.87	0.99	1.59	0.99
DCC-18	Gravel	4/27/2022	13:27:25	17.709400	-64.769390	1973.99	369.33	19.60	36.89	-0.41	0.97	-0.41	0.97	1.65	0.99	1.52	0.99
Average	Gravel	4/27/2022	13:23:53	17.709400	-64.769390	1974.35	370.65	19.92	37.25	-0.66		-0.46		nd		1.53	
Standard Deviation				17.709400	-64.769390	8.10	1.19	0.33	0.54	0.36		0.07		na		0.06	
	T			T	1	1	1			1	1						
DCC-17	Grass	4/27/2022	13:33:51	17.709600	-64.768500	1961.37	368.94	19.75	38.16	-0.91	1.00	-0.91	1.00	1.31	0.98	1.13	0.98
DCC-17	Grass	4/27/2022	13:35:37	17.709600	-64.768500	1972.80	368.41	19.90	38.91	-1.00	1.00	-1.00	1.00	1.15	0.98	1.09	0.98
DCC-17	Grass	4/27/2022	13:37:23	17.709600	-64.768500	1966.09	366.34	19.67	38.12	-0.93	1.00	-0.93	1.00	1.11	0.98	1.11	0.98
Average	Grass	4/27/2022	13:33:51	17.709600	-64.768500	1966.75	367.90	19.77	38.40	-0.95		-0.95		nd		1.11	
Standard Deviation				17.709600	-64.768500	5.75	1.37	0.12	0.45	0.05		0.05		na		0.02	-
DCC-VW18-1	Grass	4/28/2022	08:59:21	17.710690	-64.771180	1951.36	624.37	19.82	27.99	-1.12	1.00	-1.12	1.00	7.11	0.71	7.11	0.71
DCC-VW18-1	Grass	4/28/2022	09:01:07	17.710690	-64.771180	1951.62	353.55	20.19	28.42	-1.16	1.00	-1.16	1.00	8.13	1.00	7.76	1.00
DCC-VW18-1	Grass	4/28/2022	09:02:53	17.710690	-64.771180	1950.96	351.77	20.02	28.38	-1.13	1.00	-1.13	1.00	7.61	1.00	7.47	1.00
Average	Grass	4/28/2022	08:59:21	17.710690	-64.771180	1951.31	443.23	20.01	28.27	-1.14	1.00	-1.14	2.00	7.87	1.00	7.62	1.00
Standard Deviation	5.000	,,==,====		17.710690	-64.771180	0.34	156.87	0.19	0.24	0.02		0.02		0.37		0.20	
											l l						
DCC-MM9	Managed Turf	4/28/2022	09:12:20	17.714670	-64.773010	1945.07	339.62	19.11	28.78	-2.41	1.00	-2.41	1.00	5.24	1.00	4.41	0.99
DCC-MM9	Managed Turf	4/28/2022	09:14:06	17.714670	-64.773010	1944.64	339.69	19.03	29.21	-2.38	0.99	-2.38	0.99	6.79	1.00	4.53	0.99
DCC-MM9	Managed Turf	4/28/2022	09:15:52	17.714670	-64.773010	1945.65	338.75	19.28	29.26	-2.00	1.00	-2.00	1.00	4.35	0.99	3.69	0.99
Average	Managed Turf	4/28/2022	09:12:20	17.714670	-64.773010	1945.12	339.35	19.14	29.08	-2.27		-2.27		5.46		4.21	
Standard Deviation				17.714670	-64.773010	0.51	0.52	0.13	0.27	0.23		0.23		1.23		0.46	
DCC-VW15-1	Asphalt	4/28/2022	09:24:51	17.711540	-64.770090	1985.25	378.95	18.67	32.05	-0.63	0.99	-0.63	0.99	17.45	0.99	17.45	0.99
DCC-VW15-1	Asphalt	4/28/2022	09:26:36	17.711540	-64.770090	1967.11	375.49	18.66	32.31	-0.52	0.98	-0.52	0.98	17.82	0.99	17.82	0.99
DCC-VW15-1	Asphalt	4/28/2022	09:28:22	17.711540	-64.770090	1955.97	375.25	18.36	31.55	-0.47	0.99	-0.47	0.99	16.77	1.00	16.77	1.00
Average	Asphalt	4/28/2022	09:24:51	17.711540	-64.770090	1969.45	376.56	18.56	31.97	-0.54		-0.54		17.34		17.34	
Standard Deviation				17.711540	-64.770090	14.78	2.07	0.17	0.39	0.08		0.08		0.53		0.53	
DCC-3-1	Grass	4/28/2022	09:34:04	17.712330	-64.769900	1956.16	328.31	18.84	31.14	-0.78	1.00	-0.78	1.00	1.46	0.99	1.46	0.99
DCC-3-1	Grass	4/28/2022	09:35:50	17.712330	-64.769900	1952.17	331.28	19.16	32.43	-0.74	1.00	-0.74	1.00	1.74	0.99	1.41	0.98
DCC-3-1	Grass	4/28/2022	09:37:36	17.712330	-64.769900	1951.99	329.01	19.07	32.28	-0.82	1.00	-0.82	1.00	1.56	0.99	1.41	0.99
Average	Grass	4/28/2022	09:34:04	17.712330	-64.769900	1953.44	329.53	19.02	31.95	-0.78	1.00	-0.78	1.00	nd	0.55	1.43	0.55
Standard Deviation	Grass	4, 20, 2022	03.34.04	17.712330	-64.769900	2.36	1.55	0.16	0.71	0.04		0.04		na		0.03	
2000000	I	_1			1 05550				1	1 220.	1						
DCC-VW5	Grass	4/28/2022	09:44:32	17.711610	-64.769440	1974.11	337.33	19.02	32.73	-0.69	0.99	-0.69	0.99	3.35	1.00	2.98	1.00
DCC-VW5	Grass	4/28/2022	09:46:18	17.711610	-64.769440	1976.61	337.74	19.12	33.33	-0.69	1.00	-0.69	1.00	3.71	1.00	2.92	0.99
DCC-VW5	Grass	4/28/2022	09:48:04	17.711610	-64.769440	1965.18	337.06	19.37	33.96	-0.66	1.00	-0.66	1.00	3.39	1.00	2.79	1.00
Average	Grass	4/28/2022	09:44:32	17.711610	-64.769440	1971.97	337.38	19.17	33.34	-0.68		-0.68		3.48		2.90	
Standard Deviation						6.01	0.34	0.18	0.61	0.02		0.02		0.20		0.10	
DCC VAMA 2B	Crass	4/28/2022	09:55:30	17.710490	-64.769890	1070 30	330.55	10 11	33.72	1 22	0.91	0.42	0.00	2.37	0.99	2.19	0.99
DCC-VW13B DCC-VW13B	Grass	4/28/2022	09:55:30	17.710480 17.710480	-64.769890	1970.28 1966.31	330.55 331.24	19.11 19.57	33.72	-1.32 2.96	0.91	-0.13 0.01	0.69 0.01	2.37	0.99	2.19	0.99
DCC-VW13B	Grass Grass	4/28/2022	09:57:16	17.710480	-64.769890	1966.31	331.24	19.57	33.92	-0.09	0.34	-0.09	0.01	2.06	0.99	2.00	0.99
Average	Grass Grass	4/28/2022 4/28/2022	09:59:02 09:55:30	17.710480 17.710480	-64.769890 - 64.769890	1976.03 1970.87	330.66 330.82	19.18 19.29	32.95 33.53	-0.09	0.75		0.75	2.74	0.33	2.00 2.07	0.38
	Glass	4/ 20/ 2022	03.33.30	17.710480	-64.769890	4.89	0.37	0.24	0.51	1		na		0.34		0.11	
Standard Deviation				17.710480	-04.709890	4.89	0.37	0.24	0.51	na		na		0.34		0.11	<u>. </u>



										I							
			a						1_	Dry CH ₄ Flux	Dry CO ₂ Flux						
Location	Ground Cover	Date	Start Time	Latitude	Longitude	Dry CH₄	Dry CO ₂	H₂O	Temperature	(Exponential fit)	(Exponential fit)	(Linear fit)	(Linear fit)	(Exponential fit)	(Exponential fit)	(Linear fit)	(Linear fit)
		1/00/0000	40.04.55	4==40400			222.22		1	0.05	0.10		1	2.22			T
DCC-VW13B-DUP	Grass	4/28/2022	10:01:57	17.710480	-64.769890	1957.19	330.88	19.88	33.28	-0.05	0.40	-0.04	0.41	2.29	0.99	2.13	0.99
DCC-VW13B-DUP	Grass	4/28/2022	10:03:43	17.710480	-64.769890	1959.71	331.14	19.53	32.71	-0.07	0.71	-0.07	0.71	2.35	0.99	2.11	0.99
DCC-VW13B-DUP	Grass	4/28/2022	10:05:29	17.710480	-64.769890	1964.02	331.00	19.59	32.58	-0.11	0.89	-0.11	0.89	2.40	0.99	2.03	0.99
Average	Grass	4/28/2022	10:01:57	17.710480	-64.769890	1960.31	331.01	19.67	32.86	na		na		2.35		2.09	
Standard Deviation				17.710480	-64.769890	3.45	0.13	0.19	0.37	na		na		0.05		0.05	
DCC-16	Classed Court	4/20/2022	10:11:34	17.710400	-64.768800	1055.00	330.44	10.77	32.80	-0.47	0.97	-0.23	0.96	2.01	0.99	1.91	0.00
	Cleared Scrub	4/28/2022	10:11:34	17.710400	-64.768800	1955.68	330.44	18.77 18.93	-	-0.47	0.98	-0.23	0.98	2.01	0.99	1.91	0.99
DCC-16	Cleared Scrub	4/28/2022		17.710400	+	1954.99			33.25								
DCC-16	Cleared Scrub	4/28/2022	10:15:05	17.710400	-64.768800	1954.73	330.02	19.00	33.21	-0.19	0.97	-0.19	0.97	2.74	0.99	1.82	0.98
Average	Cleared Scrub	4/28/2022	10:11:34	17.710400	-64.768800	1955.14	330.22	18.90	33.09	-0.29		-0.21		2.29		1.87	
Standard Deviation				17.710400	-64.768800	0.49	0.21	0.12	0.25	0.15		0.02		0.40		0.05	
DCC 24	Croval	4/20/2022	10.22.01	17.710550	C4 770C00	1051 10	220.74	10.27	20.01	0.00	0.00	0.00	0.00	2.20	0.00	2.21	0.00
DCC-24	Gravel	4/28/2022	10:23:01	17.710550	-64.770690	1951.10	330.74	19.27	30.91	-0.99	0.99	-0.99	0.99	3.28	0.99	2.31	0.98
DCC-24	Gravel	4/28/2022	10:24:47	17.710550	-64.770690	1949.66	334.39	19.39	31.46	-1.22	0.99	-1.22	0.99	3.82	0.99	2.86	0.98
DCC-24	Gravel	4/28/2022	10:26:33	17.710550	-64.770690	1952.57	329.53	19.68	31.41	-1.55	0.98	-0.55	0.91	2.73	0.98	1.53	0.96
Average	Gravel	4/28/2022	10:23:01	17.710550	-64.770690	1951.11	331.55	19.44	31.26	-1.25		-0.92		3.28		2.23	
Standard Deviation				17.710550	-64.770690	1.46	2.53	0.21	0.30	0.28		0.34	<u> </u>	0.55		0.67	<u> </u>
DCC F	Cravel	4/20/2022	10.22.54	17 712/10	64 771150	1051 20	222.45	10 04	21 72	1.00	1.00	1 00	1.00	0.67	0.87	0.45	0.05
DCC-5	Gravel Gravel	4/28/2022 4/28/2022	10:33:54 10:35:40	17.712410 17.712410	-64.771150 -64.771150	1951.20 1950.71	323.15 322.65	18.84 18.79	31.73 32.20	-1.08 -1.05	1.00 1.00	-1.08 -1.05	1.00	0.67	0.87	0.45	0.85 0.78
1		+			+				+							0.47	
DCC-5	Gravel	4/28/2022 4/28/2022	10:37:26 10:33:54	17.712410	-64.771150 - 64.771150	1950.62 1950.84	323.41 323.07	18.93 18.85	32.05 31.99	-1.16 - 1.10	1.00	-1.16 - 1.10	1.00	0.46 nd	0.77	0.40 nd	0.77
Average	Gravel	4/20/2022	10.55.54	17.712410	+				+					1			_
Standard Deviation				17.712410	-64.771150	0.31	0.39	0.07	0.24	0.06		0.06		na		na	
DCC-6	Grass	4/28/2022	10:45:10	17.712220	-64.772180	1952.65	331.44	19.32	32.33	-0.47	0.99	-0.47	0.99	1.60	0.99	1.54	0.99
DCC-6	Grass	4/28/2022	10:46:56	17.712220	-64.772180	1952.37	330.57	19.32	32.78	-0.56	0.99	-0.56	0.99	1.98	0.99	1.61	0.98
DCC-6	Grass	4/28/2022	10:48:43	17.712220	-64.772180	1952.30	332.71	19.62	33.17	-0.49	0.99	-0.49	0.99	1.50	0.99	1.42	0.99
 		4/28/2022	10:45:10	17.712220	-64.772180 -64.772180	1952.44	331.57	19.02	32.76	-0.49	0.55	-0.49	0.55	nd	0.55	1.52	0.55
Average Standard Deviation	Grass	4/20/2022	10:45:10	17.712220	-64.772180	0.19	1.08	0.18	0.42	0.04		0.04		na		0.10	+
Standard Deviation				17.712220	-04.772180	0.15	1.08	0.16	0.42	0.04		0.04		IIa		0.10	<u>I</u>
DCC-VW24	Grass	4/28/2022	10:54:20	17.711480	-64.773060	1951.67	329.26	18.82	32.31	-0.78	1.00	-0.78	1.00	2.01	0.99	1.28	0.98
1		+			+	1951.58			+		1.00		1.00	1.21	0.98	1.21	0.98
DCC-VW24	Grass	4/28/2022	10:56:06	17.711480	-64.773060		328.98	18.83	33.15 32.93	-0.78 -0.77		-0.78		1.36		1.36	+
DCC-VW24	Grass	4/28/2022	10:57:52	17.711480	-64.773060 - 64.773060	1951.77	326.92	18.59	+		1.00	-0.77 - 0.78	1.00	1	0.99		0.99
Average	Grass	4/28/2022	10:54:20	17.711480	+	1951.67	328.39 1.28	18.75 0.13	32.80	-0.78				nd		1.28 0.07	
Standard Deviation				17.711480	-64.773060	0.09	1.20	0.13	0.43	0.00		0.00		na		0.07	<u>I</u>
DCC-VW31B	Grass	4/28/2022	11:06:14	17.709870	-64.775990	1958.16	336.49	19.43	32.54	-0.87	1.00	-0.87	1.00	4.65	0.99	3.72	0.99
DCC-VW31B	Grass	4/28/2022	11:08:00	17.709870	-64.775990	1952.26	334.65	18.97	32.02	-0.87	0.99	-0.83	0.99	4.80	0.99	3.93	0.99
DCC-VW31B	Grass	4/28/2022	11:08:00	17.709870	-64.775990	1952.26	336.21	19.26	31.98	-0.83	0.99	-0.83	0.99	3.62	1.00	3.93	1.00
Average	Grass	4/28/2022	11:06:14	17.709870	-64.775990 -64.775990	1955.48	335.78	19.20	32.18	-0.85	0.99	-0.85	0.33	4.36	1.00	3.76	1.00
Standard Deviation	Gidoo	7/ 20/ 2022	11.00.14	17.709870	-64.775990	2.99	0.99	0.23	0.32	0.02		0.02		0.64		0.16	
Januara Deviation		_1		17.703070	04.773330	,	5.55	0.23	0.52	0.02		0.02	l .	0.07		0.10	
DCC-VW31BDUP	Grass	4/28/2022	11:12:38	17.709870	-64.775990	1951.68	331.79	18.78	30.92	-0.88	1.00	-0.88	1.00	4.49	1.00	4.10	1.00
DCC-VW31BDUP	Grass	4/28/2022	11:14:23	17.709870	-64.775990	1951.47	334.25	18.87	31.21	-0.92	0.99	-0.92	0.99	4.03	1.00	3.82	1.00
DCC-VW31BDUP	Grass	4/28/2022	11:14:23	17.709870	-64.775990	1953.07	345.48	18.96	31.02	-0.89	0.99	-0.89	0.99	4.78	1.00	3.94	1.00
Average	Grass	4/28/2022	11:12:38	17.709870	-64.775990	1952.07	337.17	18.87	31.05	-0.90	5.55	-0.90	0.55	4.43	1.00	3.95	1.00
Standard Deviation	J. 033	7, 20, 2022	11,12,170	17.709870	-64.775990	0.87	7.30	0.09	0.14	0.02		0.02		0.38		0.14	
Standard Deviation				17.703070	04.773330	0.07	7.50	0.05	0.14	0.02		U.UL	l .	0.50		0.17	<u> </u>
DCC-VW18-2	Grass	4/28/2022	12:26:49	17.710700	-64.771120	1948.84	356.80	19.63	31.83	-1.14	1.00	-1.14	1.00	8.91	1.00	7.78	1.00
DCC-VW18-2	Grass	4/28/2022	12:28:35	17.710700	-64.771120	1953.06	351.26	19.75	31.99	-1.11	1.00	-1.11	1.00	7.10	1.00	7.10	1.00
DCC-VW18-2	Grass	4/28/2022	12:30:21	17.710700	-64.771120	1957.75	350.66	19.22	31.58	-1.06	1.00	-1.06	1.00	7.23	1.00	6.87	1.00
Average	Grass	4/28/2022	12:26:49	17.710700	-64.771120	1953.21	352.91	19.53	31.80	-1.10	2.00	-1.10	2.00	7.75	2.00	7.25	2.00
Standard Deviation		-,,		17.710700	-64.771120	4.46	3.39	0.28	0.20	0.04		0.04		1.01		0.47	<u> </u>
		I		27 107.00	5 , 1125		2.33	5,20	3.20	1		7.0 7	<u>I</u>		1	÷	1



DCC Results and Calculations

Draft Phase 2 Natural Source Zone Depletion Assessment Report

St. Croix Alumina Site

St. Croix, U.S. Virgin Islands

										D 011 El	5 au 5	5 0U E	5 01 5	D 60 FI	D 00 FI	D 00 El	D 60 Fl
										Dry CH₄ Flux	Dry CH₄ Flux	Dry CH ₄ Flux	Dry CH ₄ Flux	Dry CO ₂ Flux			
Location	Ground Cover	Date	Start Time	Latitude	Longitude	Dry CH₄	Dry CO ₂	H ₂ O	Temperature	(Exponential fit)	(Exponential fit)	(Linear fit)	(Linear fit)	(Exponential fit)	(Exponential fit)	(Linear fit)	(Linear fit)
DCC-3-2	Grass	4/28/2022	12:38:03	17.712370	-64.769910	1949.94	327.86	18.33	31.98	-0.85	1.00	-0.85	1.00	0.46	0.86	0.37	0.86
DCC-3-2	Grass	4/28/2022	12:39:49	17.712370	-64.769910	1950.61	328.33	18.70	33.24	-0.86	1.00	-0.86	1.00	0.48	0.92	0.48	0.92
DCC-3-2	Grass	4/28/2022	12:41:35	17.712370	-64.769910	1950.60	331.50	19.20	34.75	-0.96	1.00	-0.96	1.00	1.15	0.96	0.98	0.96
Average	Grass	4/28/2022	12:38:03	17.712370	-64.769910	1950.38	329.23	18.74	33.32	-0.89		-0.89		nd		0.73	i
Standard Deviation				17.712370	-64.769910	0.38	1.98	0.44	1.39	0.06		0.06		na		0.35	
DCC-VW18-3	Grass	4/28/2022	14:42:14	17.710740	-64.771190	1960.94	380.49	19.53	32.93	-1.17	1.00	-1.17	1.00	5.90	0.99	5.84	0.99
DCC-VW18-3	Grass	4/28/2022	14:44:00	17.710740	-64.771190	1958.33	370.30	19.21	33.17	-1.20	1.00	-1.20	1.00	6.75	0.99	5.74	0.99
DCC-VW18-3	Grass	4/28/2022	14:45:46	17.710740	-64.771190	1951.20	361.14	19.25	33.39	-1.12	1.00	-1.12	1.00	6.13	1.00	6.13	1.00
Average	Grass	4/28/2022	14:42:14	17.710740	-64.771190	1956.83	370.64	19.33	33.16	-1.16		-1.16		6.26		5.90	
Standard Deviation				17.710740	-64.771190	5.04	9.68	0.17	0.23	0.04		0.04		0.44		0.20	1
•		•			•				•		•		•				
DCC-VW15DUP	Asphalt	4/28/2022	14:52:22	17.711610	-64.770070	1950.32	371.67	17.95	32.28	-0.48	0.99	-0.48	0.99	15.65	1.00	15.55	1.00
DCC-VW15DUP	Asphalt	4/28/2022	14:54:08	17.711610	-64.770070	1949.65	378.79	17.84	32.29	-0.55	0.99	-0.55	0.99	18.80	0.99	18.80	0.99
DCC-VW15DUP	Asphalt	4/28/2022	14:55:54	17.711610	-64.770070	1949.81	373.99	18.11	32.87	-0.49	0.98	-0.49	0.98	17.61	0.98	17.61	0.98
Average	Asphalt	4/28/2022	14:52:22	17.711610	-64.770070	1949.92	374.82	17.97	32.48	-0.51		-0.51		17.35		17.32	1
Standard Deviation				17.711610	-64.770070	0.35	3.63	0.14	0.34	0.04		0.04		1.59		1.64	í
•		•			•				-		•						
DCC-3-3	Grass	4/28/2022	15:00:49	17.712380	-64.769940	1947.32	314.71	18.26	33.44	-0.85	1.00	-0.85	1.00	0.52	0.80	0.38	0.79
DCC-3-3	Grass	4/28/2022	15:02:35	17.712380	-64.769940	1947.37	314.14	18.04	34.08	-0.83	1.00	-0.83	1.00	0.50	0.87	0.44	0.87
DCC-3-3	Grass	4/28/2022	15:04:20	17.712380	-64.769940	1947.43	313.21	17.75	33.92	-0.80	1.00	-0.80	1.00	0.67	0.94	0.57	0.93
Average	Grass	4/28/2022	15:00:49	17.712380	-64.769940	1947.37	314.02	18.02	33.81	-0.83		-0.83		nd		nd	
Standard Deviation				17.712380	-64.769940	0.06	0.76	0.26	0.33	0.02		0.02		na		na	

Notes:

Value rejected due to R² value less than 0.9 and excluded from calculation

μmol·m⁻²s⁻¹ = micromole per meter square per second

 μ mol·mol⁻¹ = micromole per mole

°C = Degrees centigrade

CH₄ = methane

CO₂ = carbon dioxide

DCC = Dynamic closed chamber

DUP = duplicate

 $mmol \cdot mol^{-1} = millimole per mole$

na = Not applicable

nd = Not detected

 $nmol \cdot m^{-2}s^{-1} = nanomole per meter square per second$

nmol·mol⁻¹ = nanomole per mole

R² = Regression correlation coefficient

WGS 1983 = World Geodetic System of 1983



Table A-4

Temperature Profile Comparisons - Upgradient, Source, and Downgradient Wells Draft Phase 2 Natural Source Zone Depletion Assessment Report St. Croix Alumina Site St. Croix, U.S. Virgin Islands

Well	T Minimum (°C)	T Average (°C)	T Maximum (°C)
Background wells (MMX	, MM9, and VW10)		
2 ft bgs	25.5	25.7	26.0
1/4 to Water Table	26.2	26.7	27.0
Halfway to Water Table	26.7	27.3	27.8
3/4 to Water Table	27.1	27.6	28.0
1 ft Above Groundwater	27.3	27.8	28.0
1 ft Below Groundwater	27.2	27.5	27.9
5 ft Below Groundwater	27.1	27.4	27.8
10 ft Below Groundwate	27.1	27.4	27.8
Downgradient wells (VV	/25, VW27, VW34, VW3	7, GM11, and GM14)	
2 ft bgs	26.5	28.9	32.4
1/4 to Water Table	27.0	29.3	32.2
Halfway to Water Table	27.3	29.5	32.0
3/4 to Water Table	27.4	29.7	31.9
1 ft Above Groundwater	27.8	29.9	31.9
1 ft Below Groundwater	27.8	29.7	31.7
5 ft Below Groundwater	27.8	29.5	31.3
10 ft Below Groundwate	27.8	29.4	31.2



Temperature Profile Comparisons - Upgradient, Source, and Downgradient Wells Draft Phase 2 Natural Source Zone Depletion Assessment Report St. Croix Alumina Site St. Croix, U.S. Virgin Islands

Well	T. (°C) [Measured = Ti]	ΔΤ (Min.) [Relative to Background]	ΔT (Av.) [Relative to Background]	ΔT (Max.) [Relative to Background]	ΔT (Min.) [Relative to Downgradient]	ΔT (Av.) [Relative to Downgradient]	ΔT (Max.) [Relative to Downgradient]
Source Area Well VW-2			•	•	•		
2 ft bgs	29.2	3.2	3.5	3.7	3.2	3.5	3.7
1/4 to Water Table	29.6	2.6	2.9	3.4	2.6	2.9	3.4
Halfway to Water Table	29.8	2.0	2.5	3.1	2.0	2.5	3.1
3/4 to Water Table	30.1	2.1	2.5	3.0	2.1	2.5	3.0
1 ft Above Groundwater	30.3	2.3	2.5	3.0	2.3	2.5	3.0
1 ft Below Groundwater	30.2	2.3	2.7	3.0	2.3	2.7	3.0
5 ft Below Groundwater	30.1	2.3	2.7	3.0	2.3	2.7	3.0
10 ft Below Groundwater	30.0	2.2	2.6	2.9	2.2	2.6	2.9
Source Area Well VW-5				•			
2 ft bgs	24.5	-1.5	-1.2	-1.0	-7.9	-4.4	-2.0
1/4 to Water Table	25.4	-1.6	-1.3	-0.8	-6.8	-3.9	-1.6
Halfway to Water Table	26.3	-1.5	-1.0	-0.4	-5.7	-3.2	-1.0
3/4 to Water Table	27.2	-0.8	-0.4	0.1	-4.7	-2.5	-0.2
1 ft Above Groundwater	28.2	0.2	0.4	0.9	-3.7	-1.7	0.4
1 ft Below Groundwater	29.0	1.1	1.5	1.8	-2.7	-0.7	1.2
5 ft Below Groundwater	29.4	1.6	2.0	2.3	-1.9	-0.1	1.6
10 ft Below Groundwater	29.4	1.6	2.0	2.3	-1.8	0.0	1.6
Source Area Well VW-6				•			
2 ft bgs	27.8	1.8	2.1	2.3	-4.6	-1.1	1.3
1/4 to Water Table	28.4	1.4	1.7	2.2	-3.8	-0.9	1.4
Halfway to Water Table	28.9	1.1	1.6	2.2	-3.1	-0.6	1.6
3/4 to Water Table	29.4	1.4	1.8	2.3	-2.5	-0.3	2.0
1 ft Above Groundwater	29.5	1.5	1.7	2.2	-2.4	-0.4	1.7
1 ft Below Groundwater	29.6	1.7	2.1	2.4	-2.1	-0.1	1.8
5 ft Below Groundwater	29.6	1.8	2.2	2.5	-1.7	0.1	1.8
10 ft Below Groundwater	29.6	1.8	2.2	2.5	-1.6	0.2	1.8
Source Area Well VW-13							
2 ft bgs	29.4	3.4	3.7	3.9	-3.0	0.5	2.9
1/4 to Water Table	29.6	2.6	2.9	3.4	-2.6	0.3	2.6
Halfway to Water Table	29.5	1.7	2.2	2.8	-2.5	0.0	2.2
3/4 to Water Table	30.3	2.3	2.7	3.2	-1.6	0.6	2.9
1 ft Above Groundwater	30.8	2.8	3.0	3.5	-1.1	0.9	3.0
1 ft Below Groundwater	31.0	3.1	3.5	3.8	-0.7	1.3	3.2
5 ft Below Groundwater	30.9	3.1	3.5	3.8	-0.4	1.4	3.1
	•		1	1	1		

3.4

3.7

-0.4

1.4

3.0



10 ft Below Groundwater

30.8

3.0

Temperature Profile Comparisons - Upgradient, Source, and Downgradient Wells Draft Phase 2 Natural Source Zone Depletion Assessment Report St. Croix Alumina Site

Well	T. (°C) [Measured = Ti]	ΔT (Min.) [Relative to Background]	ΔT (Av.) [Relative to Background]	ΔT (Max.) [Relative to Background]	ΔT (Min.) [Relative to Downgradient]	ΔT (Av.) [Relative to Downgradient]	ΔT (Max.) [Relative to Downgradient]
Source Area Well VW-13B							
2 ft bgs	28.6	2.6	2.9	3.1	-3.8	-0.3	2.1
1/4 to Water Table	28.5	1.5	1.8	2.3	-3.7	-0.8	1.5
Halfway to Water Table	29.1	1.3	1.8	2.4	-2.9	-0.4	1.8
3/4 to Water Table	29.7	1.7	2.1	2.6	-2.2	0.0	2.3
1 ft Above Groundwater	30.4	2.4	2.6	3.1	-1.5	0.5	2.6
1 ft Below Groundwater	30.8	2.9	3.3	3.6	-0.9	1.1	3.0
5 ft Below Groundwater	30.8	3.0	3.4	3.7	-0.5	1.3	3.0
10 ft Below Groundwater	30.7	2.9	3.3	3.6	-0.5	1.3	2.9
Source Area Well VW-14							
2 ft bgs	27.3	1.3	1.6	1.8	-5.1	-1.6	0.8
1/4 to Water Table	27.9	0.9	1.2	1.7	-4.3	-1.4	0.9
Halfway to Water Table	28.5	0.7	1.2	1.8	-3.5	-1.0	1.2
3/4 to Water Table	29.0	1.0	1.4	1.9	-2.9	-0.7	1.6
1 ft Above Groundwater	29.7	1.7	1.9	2.4	-2.2	-0.2	1.9
1 ft Below Groundwater	29.8	1.9	2.3	2.6	-1.9	0.1	2.0
5 ft Below Groundwater	29.7	1.9	2.3	2.6	-1.6	0.2	1.9
10 ft Below Groundwater	29.6	1.8	2.2	2.5	-1.6	0.2	1.8
Source Area Well VW-20							
2 ft bgs	27.4	1.4	1.7	1.9	-5.0	-1.5	0.9
1/4 to Water Table	28.1	1.1	1.4	1.9	-4.1	-1.2	1.1
Halfway to Water Table	28.6	0.8	1.3	1.9	-3.4	-0.9	1.3
3/4 to Water Table	29.6	1.6	2.0	2.5	-2.3	-0.1	2.2
1 ft Above Groundwater	30.8	2.8	3.0	3.5	-1.1	0.9	3.0
1 ft Below Groundwater	31.1	3.2	3.6	3.9	-0.6	1.4	3.3
5 ft Below Groundwater	31.1	3.3	3.7	4.0	-0.2	1.6	3.3
10 ft Below Groundwater	30.9	3.1	3.5	3.8	-0.3	1.5	3.1
Source Area Well VW-20B							
2 ft bgs	30.1	4.1	4.4	4.6	-2.3	1.2	3.6
1/4 to Water Table	30.0	3.0	3.3	3.8	-2.2	0.7	3.0
Halfway to Water Table	30.0	2.2	2.7	3.3	-2.0	0.5	2.7
3/4 to Water Table	30.7	2.7	3.1	3.6	-1.2	1.0	3.3
1 ft Above Groundwater	31.2	3.2	3.4	3.9	-0.7	1.3	3.4
1 ft Below Groundwater	31.3	3.4	3.8	4.1	-0.4	1.6	3.5
5 ft Below Groundwater	31.1	3.3	3.7	4.0	-0.2	1.6	3.3
10 ft Below Groundwater	30.7	2.9	3.3	3.6	-0.5	1.3	2.9



Temperature Profile Comparisons - Upgradient, Source, and Downgradient Wells Draft Phase 2 Natural Source Zone Depletion Assessment Report St. Croix Alumina Site

Well	T. (°C) [Measured = Ti]	ΔT (Min.) [Relative to Background]	ΔT (Av.) [Relative to Background]	ΔT (Max.) [Relative to Background]	ΔT (Min.) [Relative to Downgradient]	ΔT (Av.) [Relative to Downgradient]	ΔT (Max.) [Relative to Downgradient]
Source Area Well VW-21B							
2 ft bgs	27.7	1.7	2.0	2.2	-4.7	-1.2	1.2
1/4 to Water Table	28.0	1.0	1.3	1.8	-4.2	-1.3	1.0
Halfway to Water Table	28.5	0.7	1.2	1.8	-3.5	-1.0	1.2
3/4 to Water Table	29.0	1.0	1.4	1.9	-2.9	-0.7	1.6
1 ft Above Groundwater	29.6	1.6	1.8	2.3	-2.3	-0.3	1.8
1 ft Below Groundwater	30.2	2.3	2.7	3.0	-1.5	0.5	2.4
5 ft Below Groundwater	30.2	2.4	2.8	3.1	-1.1	0.7	2.4
10 ft Below Groundwater	29.9	2.1	2.5	2.8	-1.3	0.5	2.1
Source Area Well VW-23							
2 ft bgs	27.8	1.8	2.1	2.3	-4.6	-1.1	1.3
1/4 to Water Table	28.4	1.4	1.7	2.2	-3.8	-0.9	1.4
Halfway to Water Table	29.0	1.2	1.7	2.3	-3.0	-0.5	1.7
3/4 to Water Table	29.5	1.5	1.9	2.4	-2.4	-0.2	2.1
1 ft Above Groundwater	30.3	2.3	2.5	3.0	-1.6	0.4	2.5
1 ft Below Groundwater	30.7	2.8	3.2	3.5	-1.0	1.0	2.9
5 ft Below Groundwater	30.6	2.8	3.2	3.5	-0.7	1.1	2.8
10 ft Below Groundwater	30.6	2.8	3.2	3.5	-0.6	1.2	2.8
Source Area Well VW-24							
2 ft bgs	30.1	4.1	4.4	4.6	-2.3	1.2	3.6
1/4 to Water Table	29.4	2.4	2.7	3.2	-2.8	0.1	2.4
Halfway to Water Table	29.0	1.2	1.7	2.3	-3.0	-0.5	1.7
3/4 to Water Table	28.9	0.9	1.3	1.8	-3.0	-0.8	1.5
1 ft Above Groundwater	29.1	1.1	1.3	1.8	-2.8	-0.8	1.3
1 ft Below Groundwater	29.1	1.2	1.6	1.9	-2.6	-0.6	1.3
5 ft Below Groundwater	28.9	1.1	1.5	1.8	-2.4	-0.6	1.1
10 ft Below Groundwater	28.7	0.9	1.3	1.6	-2.5	-0.7	0.9
Source Area Well VW-29							
2 ft bgs	27.3	1.3	1.6	1.8	-5.1	-1.6	0.8
1/4 to Water Table	27.9	0.9	1.2	1.7	-4.3	-1.4	0.9
Halfway to Water Table	28.7	0.9	1.4	2.0	-3.3	-0.8	1.4
3/4 to Water Table	29.3	1.3	1.7	2.2	-2.6	-0.4	1.9
1 ft Above Groundwater	30.3	2.3	2.5	3.0	-1.6	0.4	2.5
1 ft Below Groundwater	30.6	2.7	3.1	3.4	-1.1	0.9	2.8
5 ft Below Groundwater	30.5	2.7	3.1	3.4	-0.8	1.0	2.7
10 ft Below Groundwater	30.4	2.6	3.0	3.3	-0.8	1.0	2.6



Temperature Profile Comparisons - Upgradient, Source, and Downgradient Wells **Draft Phase 2 Natural Source Zone Depletion Assessment Report** St. Croix Alumina Site

Well	T. (°C) [Measured = Ti]	ΔT (Min.) [Relative to Background]	ΔT (Av.) [Relative to Background]	ΔT (Max.) [Relative to Background]	ΔT (Min.) [Relative to Downgradient]	ΔT (Av.) [Relative to Downgradient]	ΔT (Max.) [Relative to Downgradient]
Source Area Well VW-30							
2 ft bgs	25.8	-0.2	0.1	0.3	-6.6	-3.1	-0.7
1/4 to Water Table	26.1	-0.9	-0.6	-0.1	-6.1	-3.2	-0.9
Halfway to Water Table	26.5	-1.3	-0.8	-0.2	-5.5	-3.0	-0.8
3/4 to Water Table	26.9	-1.1	-0.7	-0.2	-5.0	-2.8	-0.5
1 ft Above Groundwater	28.5	0.5	0.7	1.2	-3.4	-1.4	0.7
1 ft Below Groundwater	29.1	1.2	1.6	1.9	-2.6	-0.6	1.3
5 ft Below Groundwater	29.1	1.3	1.7	2.0	-2.2	-0.4	1.3
10 ft Below Groundwater	29.0	1.2	1.6	1.9	-2.2	-0.4	1.2
Source Area Well VW-31							
2 ft bgs	28.9	2.9	3.2	3.4	-3.5	0.0	2.4
1/4 to Water Table	29.2	2.2	2.5	3.0	-3.0	-0.1	2.2
Halfway to Water Table	29.2	1.4	1.9	2.5	-2.8	-0.3	1.9
3/4 to Water Table	29.5	1.5	1.9	2.4	-2.4	-0.2	2.1
1 ft Above Groundwater	29.9	1.9	2.1	2.6	-2.0	0.0	2.1
1 ft Below Groundwater	30.2	2.3	2.7	3.0	-1.5	0.5	2.4
5 ft Below Groundwater	30.1	2.3	2.7	3.0	-1.2	0.6	2.3
10 ft Below Groundwater	30.1	2.3	2.7	3.0	-1.1	0.7	2.3
Source Area Well VW-32							
2 ft bgs	28.3	2.3	2.6	2.8	-4.1	-0.6	1.8
1/4 to Water Table	28.6	1.6	1.9	2.4	-3.6	-0.7	1.6
Halfway to Water Table	28.9	1.1	1.6	2.2	-3.1	-0.6	1.6
3/4 to Water Table	29.2	1.2	1.6	2.1	-2.7	-0.5	1.8
1 ft Above Groundwater	29.8	1.8	2.0	2.5	-2.1	-0.1	2.0
1 ft Below Groundwater	30.0	2.1	2.5	2.8	-1.7	0.3	2.2
5 ft Below Groundwater	29.8	2.0	2.4	2.7	-1.5	0.3	2.0
10 ft Below Groundwater	29.7	1.9	2.3	2.6	-1.5	0.3	1.9
Source Area Well VW-35							
2 ft bgs	25.2	-0.8	-0.5	-0.3	-7.2	-3.7	-1.3
1/4 to Water Table	25.9	-1.1	-0.8	-0.3	-6.3	-3.4	-1.1
Halfway to Water Table	26.5	-1.3	-0.8	-0.2	-5.5	-3.0	-0.8
3/4 to Water Table	27.0	-1.0	-0.6	-0.1	-4.9	-2.7	-0.4
1 ft Above Groundwater	27.7	-0.3	-0.1	0.4	-4.2	-2.2	-0.1
1 ft Below Groundwater	28.5	0.6	1.0	1.3	-3.2	-1.2	0.7
5 ft Below Groundwater	28.5	0.7	1.1	1.4	-2.8	-1.0	0.7
10 ft Below Groundwater	28.5	0.7	1.1	1.4	-2.7	-0.9	0.7



Temperature Profile Comparisons - Upgradient, Source, and Downgradient Wells Draft Phase 2 Natural Source Zone Depletion Assessment Report St. Croix Alumina Site St. Croix, U.S. Virgin Islands

Notes:

°C = degrees Centigrade

Av. = average

bgs = below ground surface

ft = feet/foot

Max. = maximum

Min. = minimum

T = temperature

Tb = temperature in background well

Ti = temperature of well "i"

 ΔT = temperature difference



Statistical Comparison for Well Headspace Gas Readings Draft Phase 2 Natural Source Zone Depletion Assessment Report

St. Croix Alumina Site

St. Croix, U.S. Virgin Islands

				t-	test		Wilc	oxon rank-su	m test	50) % Quantile	Test
Analyte	Unit	Variance	DF	Statistic	p-value	Area > Background?	Statistic	p-value	Area > Background	Statistic	p-value	Area > Background
Methane	% Vol	UnEqual	15.1	3.3	0.002	Yes	70.5	0.006	Yes	13.5	0.061	No
Carbon dioxide	% Vol	UnEqual	18.7	11.4	< 0.001	Yes	76.5	0.001	Yes	16.4	0.027	Yes
Hydrogen sulfide	ppm	UnEqual	15	1.7	0.059	No	57.5	0.047	Yes			

Notes:

Comparison of means was evaluated using one-sided two-sample t tests with 95% confidence levels ($\alpha = 0.05$).

Non-parametric comparison was evaluated using one-sided Wilcoxon rank sum tests (means) with 95% confidence levels and 50% Quantile tests (medians) with α = 0.05. Generic Hypotheses:

Null hypothesis: Area mean/median is less than or equal to the background mean/median ($x \le y$).

Alternative hypothesis: Area mean/median is greater than background mean/median (x > y).

-- = Quantile tests were not run when all background values were measured as 0 ppm hydrogen sulfide.

% Vol = percent by volume

DF = degrees of freedom

ppm = parts per million



NSZD Rate Calculations Based on Groundwater Temperature Draft Phase 2 Natural Source Zone Depletion Assessment Report

St. Croix Alumina Site St. Croix, U.S. Virgin Islands

ĺ	Thermal Proper	ties of Medium	
ĺ	Specific Heat of Water	J/kg*K	4184

Ground	water Flow	
K = Hydraulic Conductivity	ft/day	50.4
ft/day to m/day		0.3048
K = Hydraulic Conductivity	m/day	15.4
Y = Average width of LNAPL footprint	m	730.3
Z = Average thickness of the smear zone	m	3.048
YZ = Area of Heating	m ²	2226
i = dh/dx = Groundwater Gradient	ft/ft	0.0007
Q = Volumetric Flow Rate	m³/day	23.9
ṁ = Mass Flow Rate (assume ρ _{water} = 1000 kg/m³)	kg/day	23936.5
kg/day to kg/sec		1.157E-05
m = Mass Flow Rate	kg/sec	0.277

Temper	rature			
Background well temp	°C		27.5	
Source Area Well	°C	28.5	30.1	31.3
ΔΤ	°C	1	2.6	3.8

Power to heat flow	ing groundwa	ter		
Extractable heat (J/s)= GW flux (kg/s) * Δ T * heatcapacity (J/kg*K)	J/sec	1159	3014	4405

Methane Oxidation	on Power Sour	ce
ΔH ^o Methane oxidation (J/g of CH ₄)	J/g	53953

NSZD	Rate			
Methane needed to heat water	g/sec	0.021484546	0.05585982	0.081641275
Methane Utilization Factor (C ₁₈ H ₃₈)	unitless		1.15	
Total C ₁₈ H ₃₈ Degradation Rate	g/sec	0.024776288	0.064418348	0.094149893
convert g/sec to g/yr			31540000	
Total C ₁₈ H ₃₈ Degradation Rate	g/year	781444	2031755	2969488
	kg/year	781	2032	2969
convert kg/year to lb/year			2.20462	
	lb/year	1723	4479	6547
Density C ₁₈ H ₃₈ @ 25°C	g/mL		0.777	
Total C ₁₈ H ₃₈ Degradation Rate (mL/yr)		1005720	2614871	3821734
convert mL/year to gallon/year			0.000264172	
Total C ₁₈ H ₃₈ Degradation Rate (Gal/yr)		266	691	1010



NSZD Rate Calculations Based on Groundwater Temperature Draft Phase 2 Natural Source Zone Depletion Assessment Report St. Croix Alumina Site St. Croix, U.S. Virgin Islands

Notes:

i = groundwater dradient

dh/dx = groundwater height difference divided by distance (groundwater gradient)

 ΔH^{o} = standard enthalpy

 ΔT = temperature difference

°C = degrees Celsius

 $C_{18}H_{38}$ = octadecane

 CH_4 = methane

ft = feet

g = grams

Gal = gallons

GW = groundwater

J = Joules

kg = kilogram

lb = pounds

LNAPL = light non-aqueous phase liquid

m = meters

m² = square meters

m³ = cubic meters

mL = milliliters

NSZD = natural source zone depletion

sec = second

yr = year



Height above water table (ft)	VW13 (°C)	VW13B (°C)	VW14 (°C)	VW15 (°C)	VW16 (°C)	VW18 (°C)	VW2 (°C)	VW20 (°C)	VW20B (°C)	VW21B (°C)	VW23 (°C)	VW24 (°C)	VW25 (°C)	VW27 (°C)	VW29 (°C)	VW30 (°C)	VW31 (°C)	VW32 (°C)	VW34 (°C)	VW35 (°C)
1.00	30.76	30.34	29.69	31.42	31.13	29.79	30.35	30.61	31.22	29.55	30.25	29.10	27.80	28.73	30.22	28.22	29.81	29.70	28.16	27.70
2.00	30.68	30.25	29.61	31.43	31.15	29.74	30.32	30.51	31.14	29.49	30.16	29.09	27.76	28.67	30.13	28.11	29.78	29.66	28.16	27.65
3.00	30.60	30.17	29.53	31.44	31.17	29.68	30.29	30.41	31.06	29.44	30.06	29.07	27.73	28.61	30.04	28.00	29.76	29.62	28.15	27.61
4.00	30.51	30.08	29.45	31.45	31.20	29.62	30.26	30.31	30.98	29.38	29.96	29.05	27.69	28.54	29.95	27.89	29.73	29.58	28.15	27.56
5.00	30.43	29.99	29.37	31.45	31.22	29.57	30.23	30.21	30.91	29.32	29.87	29.04	27.65	28.48	29.86	27.79	29.70	29.54	28.14	27.51
6.00	30.36	29.91	29.29	31.45	31.24	29.51	30.20	30.11	30.83	29.26	29.77	29.02	27.61	28.41	29.77	27.68	29.68	29.49	28.14	27.47
7.00	30.28	29.82	29.21	31.46	31.27	29.46	30.18	30.01	30.76	29.20	29.68	29.00	27.58	28.35	29.68	27.57	29.65	29.45	28.14	27.42
8.00	30.21	29.74	29.13	31.46	31.29	29.40	30.15	29.91	30.69	29.15	29.58	28.99	27.54	28.28	29.59	27.47	29.62	29.41	28.13	27.38
9.00	30.14	29.66	29.05	31.45	31.32	29.35	30.12	29.81	30.62	29.09	29.48	28.97	27.50	28.22	29.50	27.37	29.60	29.37	28.13	27.33
10.00	30.07	29.58	28.97	31.44	31.34	29.29	30.09	29.71	30.56	29.03	29.39	28.96	27.47	28.16	29.41	27.27	29.57	29.33	28.13	27.28
11.00	30.00	29.50	28.89	31.43	31.36	29.24	30.06	29.61	30.50	28.97	29.29	28.95	27.43	28.09	29.32	27.18	29.54	29.29	28.12	27.24
12.00	29.94	29.42	28.81	31.42	31.39	29.18	30.03	29.51	30.44	28.91	29.20	28.93	27.39	28.03	29.23	27.09	29.52	29.25	28.12	27.19
13.00	29.89	29.35	28.73	31.39	31.41	29.12	30.01	29.41	30.39	28.85	29.10	28.92	27.35	27.96	29.14	27.00	29.49	29.20	28.11	27.15
14.00	29.83	29.27	28.65	31.37	31.43	29.07	29.98	29.31	30.33	28.80	29.00	28.91	27.32	27.90	29.05	26.91	29.46	29.16	28.11	27.10
15.00	29.78	29.20	28.57	31.34	31.46	29.01	29.95	29.21	30.29	28.74	28.91	28.90	27.28	27.83	28.96	26.83	29.44	29.12	28.11	27.05
16.00	29.73	29.13	28.49	31.30	31.48	28.96	29.92	29.11	30.24	28.68	28.81	28.89	27.24	27.77	28.87	26.75	29.41	29.08	28.10	27.01
17.00	29.69	29.06	28.41	31.26	31.50	28.90	29.89	29.01	30.21	28.62	28.72	28.89	27.20	27.71	28.78	26.67	29.38	29.04	28.10	26.96
18.00	29.65	29.00	28.33	31.21	31.53	28.85	29.86	28.91	30.17	28.56	28.62	28.88	27.17	27.64	28.69	26.60	29.36	29.00	28.09	26.92
19.00	29.61	28.93	28.25	31.16	31.55	28.79	29.83	28.81	30.14	28.50	28.52	28.88	27.13	27.58	28.60	26.53	29.33	28.96	28.09	26.87
20.00	29.57	28.87	28.17	31.11	31.57	28.73	29.81	28.71	30.11	28.45	28.43	28.87	27.09	27.51	28.51	26.46	29.30	28.91	28.09	26.82
21.00	29.54	28.81	28.09	31.04	31.60	28.68	29.78	28.61	30.09	28.39	28.33	28.87	27.06	27.45	28.42	26.40	29.28	28.87	28.08	26.78
22.00	29.50	28.75	28.01	30.98	31.62	28.62	29.75	28.51	30.07	28.33	28.24	28.87	27.02	27.38	28.33	26.34	29.25	28.83	28.08	26.73
23.00	29.47	28.69	27.93	30.90	31.65	28.57	29.72	28.41	30.06	28.27	28.14	28.87	26.98	27.32	28.24	26.28	29.22	28.79	28.07	26.69
24.00	29.44	28.63	27.85	30.82	31.67	28.51	29.69	28.31	30.04	28.21	28.04	28.87	26.94	27.26	28.15	26.22	29.20	28.75	28.07	26.64
25.00	29.41	28.57	27.77	30.74	31.69	28.46	29.66	28.21	30.03	28.15	27.95	28.88	26.91	27.19	28.06	26.17	29.17	28.71		26.59
26.00	29.39	28.51	27.69	30.65	31.72	28.40	29.64	28.11	30.03	28.10	27.85	28.88	26.87	27.13	27.96	26.12	29.14	28.67		26.55
27.00	29.36	28.45	27.61	30.55	31.74	28.34	29.61	28.01	30.02	28.04	27.76	28.89	26.83	27.06	27.87	26.08	29.12	28.63		26.50
28.00	29.33	28.39	27.53	30.45	31.76	28.29	29.58	27.91	30.02	27.98	27.66	28.89	26.79	27.00	27.78	26.03	29.09	28.58		26.46
29.00	29.30	28.33	27.45	30.35	31.79	28.23	29.55	27.81	30.02	27.92	27.56	28.90	26.76	26.93	27.69	25.99	29.06	28.54		26.41
30.00	29.27	28.28	27.37	30.24	31.81	28.18	29.52	27.71	30.02	27.86		28.92	26.72	26.87	27.60	25.94	29.04	28.50		26.36
31.00		28.22	27.29	30.13		28.12	29.49	27.61	30.03	27.80		28.93	26.68	26.81	27.51	25.90	29.01	28.46		26.32
32.00			27.21	30.02		28.07	29.47	27.51	30.03	27.75		28.94	26.64	26.74	27.42	25.86	28.98	28.42		26.27
33.00			27.13	29.90		28.01	29.44	27.41	30.03	27.69		28.96	26.61	26.68	27.33	25.82	28.96	28.38		26.23
34.00				29.78		27.96	29.41	27.31	30.04	27.63		28.98	26.57	26.61	27.24	25.78	28.93	28.34		26.18
35.00				29.66		27.90	29.38	27.21	30.04	27.57		29.00	26.53	26.55	27.15	25.74	28.90	28.29		26.13
36.00				29.54		27.90	29.35	27.11	30.04	27.51		29.02			27.06	25.70	28.88	28.25		26.09
37.00				29.42			29.32	27.01	30.05	27.45		29.04			26.97	25.66	28.85	28.21		26.04
38.00				29.29			29.29		30.05			29.07				25.62	28.82	28.17		26.00



Table A-7 Unsaturated Zone Temperature Gradient Curve Fitting and Background Subtraction

Phase 2 NSZD Study St. Croix Alumina

Height above water table (ft)	VW13 (°C)	VW13B (°C)	VW14 (°C)	VW15 (°C)	VW16 (°C)	VW18 (°C)	VW2 (°C)	VW20 (°C)	VW20B (°C)	VW21B (°C)	VW23 (°C)	VW24 (°C)	VW25 (°C)	VW27 (°C)	VW29 (°C)	VW30 (°C)	VW31 (°C)	VW32 (°C)	VW34 (°C)	VW35 (°C)
39.00				29.17			29.27					29.09						28.13		25.95
40.00				29.04			29.24					29.12								25.90
41.00				28.92			29.21					29.15								25.86
42.00				28.79								29.18								25.81
43.00				28.67								29.21								25.76
44.00												29.24								25.72
45.00												29.28								25.67
46.00												29.31								25.63
47.00												29.35								25.58
48.00										-		29.39								25.53
49.00												29.43								25.49
50.00												29.47								25.44
51.00												29.51								25.40
52.00												29.55								25.35
53.00												29.59								25.30
54.00												29.64								25.26
55.00												29.68								25.21
56.00												29.73								25.17
57.00												29.77								25.12
58.00												29.82								
59.00												29.86								
60.00												29.91								
61.00												29.96								
62.00												30.00								
63.00												30.05								



VW4 (°C)	VW5 (°C)	VW6 (°C)	VW7 (°C)	Backgroun d VW3 (°C)	Backgroun d VW8 (°C)	Backgroun d VW9R (°C)	Backgroun d VW10 (°C)	Backgroun d VW11 (°C)	Average Backgroun d Fit (°C)	VW13 Minus Average Backgroun d Fit (°C)	VW13B Minus Average Backgroun d Fit (°C)	VW14 Minus Average Backgroun d Fit (°C)	VW15 Minus Average Backgroun d Fit (°C)	VW16 Minus Average Backgroun d Fit (°C)	VW18 Minus Average Backgroun d Fit (°C)	VW2 Minus Average Backgroun d Fit (°C)	d Fit	VW20B Minus Average Backgroun d Fit (°C)	VW21B Minus Average Backgroun d Fit (°C)	VW23 Minus Average Backgroun d Fit
21.00	20.20	20.60	20.00	27.07	27.24	27.60	27.70	20.01	27.75								(°C)			(°C)
31.90	28.20 28.10	29.60 29.55	29.90 29.89	27.97 27.98	27.31 27.30	27.68 27.67	27.79 27.79	28.01 28.00	27.75 27.75	3.01 2.93	2.59 2.50	1.94 1.86	3.67 3.68	3.38 3.40	2.04 1.99	2.60 2.57	2.86 2.76	3.47 3.39	1.80 1.75	2.50 2.41
31.90 31.90	27.99	29.55	29.89	27.98	27.30	27.67	27.79	27.99	27.75	2.95	2.30	1.78	3.69	3.43	1.93	2.54	2.67	3.31	1.69	2.41
31.89	27.88	29.47	29.88	28.00	27.27	27.67	27.80	27.98	27.74	2.77	2.33	1.70	3.70	3.45	1.88	2.52	2.57	3.24	1.63	2.22
31.89	27.77	29.42	29.87	28.01	27.26	27.66	27.80	27.97	27.74	2.69	2.25	1.63	3.71	3.48	1.83	2.49	2.47	3.17	1.58	2.13
31.89	27.66	29.37	29.87	28.02	27.24	27.66	27.80	27.97	27.74	2.62	2.17	1.55	3.72	3.51	1.77	2.47	2.37	3.09	1.52	2.03
31.89	27.55	29.32	29.86	28.04	27.23	27.66	27.80	27.96	27.74	2.54	2.09	1.47	3.72	3.53	1.72	2.44	2.28	3.02	1.47	1.94
31.89	27.44	29.27	29.85	28.05	27.22	27.65	27.80	27.95	27.73	2.47	2.01	1.40	3.72	3.56	1.67	2.41	2.18	2.96	1.41	1.85
31.89	27.33	29.21	29.84	28.05	27.20	27.65	27.80	27.94	27.73	2.41	1.93	1.32	3.72	3.59	1.62	2.39	2.08	2.89	1.36	1.75
31.90	27.22	29.15	29.83	28.06	27.18	27.64	27.80	27.93	27.73	2.34	1.85	1.24	3.72	3.61	1.57	2.37	1.99	2.83	1.30	1.66
31.90	27.11	29.09	29.82	28.07	27.17	27.64	27.80	27.92	27.72	2.28	1.78	1.17	3.71	3.64	1.51	2.34	1.89	2.78	1.25	1.57
31.90	27.01	29.02	29.82	28.08	27.15	27.63	27.80	27.91	27.72	2.23	1.71	1.10	3.70	3.67	1.46	2.32	1.80	2.72	1.20	1.48
31.91	26.90	28.95	29.80	28.09	27.13	27.63	27.80	27.90	27.71	2.18	1.64	1.02	3.68	3.70	1.41	2.30	1.70	2.68	1.14	1.39
31.92	26.79	28.87	29.79	28.09	27.11	27.62	27.80	27.89	27.70	2.13	1.57	0.95	3.67	3.73	1.37	2.27	1.61	2.63	1.09	1.30
31.92	26.68	28.79	29.78	28.09	27.09	27.61	27.80	27.88	27.70	2.08	1.51	0.88	3.64	3.76	1.32	2.25	1.52	2.59	1.04	1.21
31.93	26.57	28.71	29.77	28.10	27.07	27.61	27.79	27.86	27.69	2.04	1.44	0.80	3.61	3.79	1.27	2.23	1.42	2.56	0.99	1.12
31.94	26.46	28.62	29.76	28.10	27.05	27.60	27.79	27.85	27.68	2.01	1.38	0.73	3.58	3.83	1.22	2.21	1.33	2.53	0.94	1.04
31.95	26.35	28.53	29.74	28.10	27.03	27.59	27.79	27.84	27.67	1.98	1.33	0.66	3.55	3.86	1.18	2.19	1.24	2.50	0.89	0.95
31.97	26.24	28.44	29.73	28.10	27.01	27.58	27.79	27.82	27.66	1.95	1.27	0.59	3.51	3.89	1.13	2.18	1.15	2.48	0.85	0.87
31.98	26.13	28.35	29.71	28.10	26.98	27.57	27.78	27.80	27.65	1.92	1.22	0.53	3.46	3.93	1.09	2.16	1.06	2.47	0.80	0.78
32.00	26.02	28.25	29.70	28.09	26.95	27.56	27.78	27.79	27.63	1.90	1.17	0.46	3.41	3.97	1.05	2.14	0.98	2.46	0.75	0.70
32.01	25.91	28.15	29.68	28.09	26.93	27.54	27.77	27.77	27.62	1.88	1.13	0.39	3.36	4.00	1.00	2.13	0.89	2.45	0.71	0.62
32.03	25.81	28.06	29.66	28.08	26.90	27.53	27.77	27.75	27.60	1.87	1.08	0.33	3.30	4.04	0.96	2.12	0.80	2.45	0.67	0.53
32.05	25.70	27.96	29.64	28.07	26.87	27.51	27.76	27.73	27.59	1.85	1.04	0.26	3.23	4.08	0.92	2.10	0.72	2.46	0.62	0.45
32.07	25.59	27.86	29.62	28.06	26.84	27.50	27.75	27.71	27.57	1.84	0.99	0.20	3.16	4.12	0.88	2.09	0.64	2.46	0.58	0.38
32.09	25.48	27.76	29.60	28.05	26.81	27.48	27.75	27.69	27.55	1.83	0.95	0.14	3.09	4.16	0.85	2.08	0.55	2.47	0.54	0.30
32.12	25.37	27.67	29.58	28.03	26.78	27.46	27.74	27.66	27.53	1.82	0.92	0.08	3.02	4.21	0.81	2.07	0.47	2.49	0.50	0.22
32.14	25.26	27.57	29.56	28.02	26.74	27.45	27.73	27.64	27.51	1.81	0.88	0.02	2.94	4.25	0.77	2.06	0.39	2.51	0.46	0.14
32.16	25.15		29.53	28.00	26.71	27.43	27.72	27.61	27.49	1.81	0.84	-0.04	2.86	4.29	0.74	2.06	0.31	2.53	0.43	0.07
32.19	25.04		29.51	27.98	26.67	27.40	27.71	27.59	27.47	1.80	0.81	-0.10	2.77	4.34	0.71	2.05	0.24	2.55	0.39	
32.22	24.93		29.49	27.96	26.63	27.38	27.70	27.56	27.45		0.77	-0.15	2.69		0.68	2.05	0.16	2.58	0.36	
32.24	24.82		29.46	27.93	26.59	27.36	27.69	27.53	27.42			-0.21	2.60		0.65	2.04	0.09	2.61	0.32	
32.27	24.71		29.43	27.91	26.55	27.34	27.68	27.50	27.40			-0.26	2.51		0.62	2.04	0.01	2.64	0.29	
32.30	24.61		29.41	27.88	26.51	27.31	27.66	27.47	27.37				2.42		0.59	2.04	-0.06	2.67	0.26	
32.33	24.50		29.38	27.85	26.47	27.28	27.65	27.44	27.34				2.32		0.56	2.04	-0.13	2.70	0.23	
32.35	24.39		29.35	27.82	26.43	27.26	27.63	27.41	27.31				2.23		0.59	2.04	-0.20	2.73	0.20	
32.38	24.28		29.32	27.79	26.38	27.23	27.62	27.37	27.28				2.14			2.05	-0.27	2.77	0.18	
32.41	24.17		29.29	27.76	26.34	27.20	27.60	27.34	27.25				2.05			2.05		2.81		



VW4 (°C)	VW5 (°C)	VW6 (°C)	VW7 (°C)	Backgroun d VW3 (°C)	Backgroun d VW8 (°C)	Backgroun d VW9R (°C)	Backgroun d VW10 (°C)	Backgroun d VW11 (°C)	Average Backgroun d Fit (°C)	VW13 Minus Average Backgroun d Fit (°C)	VW13B Minus Average Backgroun d Fit (°C)	VW14 Minus Average Backgroun d Fit (°C)	VW15 Minus Average Backgroun d Fit (°C)	VW16 Minus Average Backgroun d Fit (°C)	VW18 Minus Average Backgroun d Fit (°C)	VW2 Minus Average Backgroun d Fit (°C)	VW20 Minus Average Backgroun d Fit (°C)	VW20B Minus Average Backgroun d Fit (°C)	VW21B Minus Average Backgroun d Fit (°C)	VW23 Minus Average Backgroun d Fit (°C)
32.44			29.26	27.72	26.29	27.17	27.58	27.30	27.21	-			1.96			2.05			-	
32.47			29.23	27.68	26.24	27.14	27.57	27.26	27.18	-			1.87			2.06			-	
32.50			29.20	27.64	26.19	27.10	27.55	27.22	27.14				1.78			2.07				
			29.17	27.60	26.15	27.07	27.53	27.18	27.10				1.69							
			29.14	27.55	26.10	27.03	27.51	27.14	27.07				1.60							
			29.11	27.50	26.05	26.99	27.49	27.10	27.03											
			29.08	27.46	26.00	26.96	27.47	27.06	26.99											
			29.04	27.41	25.94	26.92	27.44	27.01	26.94											
			29.01	27.35	25.89	26.88	27.42	26.97	26.90											
			28.98	27.30	25.84	26.84	27.40	26.92	26.86											
			28.95	27.25	25.79	26.79	27.37	26.88	26.81											
			28.92	27.19	25.74	26.75	27.34	26.83	26.77											
			28.89	27.13	25.68	26.71	27.32	26.78	26.72											
				27.07	25.63	26.66	27.29	26.73	26.68											
				27.01	25.58	26.62	27.26	26.68	26.63											
				26.95	25.52	26.57	27.23	26.63	26.58											
				26.89	25.47	26.52	27.20	26.58	26.53											
				26.82	25.42	26.47	27.17	26.53	26.48											
				26.75	25.36	26.42	27.14	26.48	26.43											
				26.69	25.31	26.38	27.11	26.42	26.38											
				26.62	25.26	26.32	27.08	26.37	26.33											
				26.55	25.20	26.27	27.04	26.32	26.28											
				26.48	25.15	26.22	27.01	26.26	26.22											
				26.41	25.10	26.17	26.98	26.21	26.17											
				26.34	25.04	26.12	26.94	26.15	26.12											



VW24	VW25	VW27	VW29	VW30	VW31	VW32	VW34	VW35	VW4	VW5	VW6	VW7
Minus	Minus	Minus	Minus	Minus	Minus	Minus	Minus	Minus	Minus	Minus	Minus	Minus
Average	Average	Average	Average	Average	Average	Average	Average	Average	Average	Average	Average	Average
_	Backgroun	Backgroun	_	Backgroun	_	Backgroun	_	_	Backgroun	_	_	Backgroun
d Fit	d Fit	d Fit	d Fit	d Fit	d Fit	d Fit	d Fit	d Fit	d Fit	d Fit	d Fit	d Fit
(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)
1.35	0.05	0.98	2.47	0.47	2.06	1.95	0.41	-0.05	4.15	0.45	1.85	2.15
1.34	0.02	0.92	2.38	0.36	2.04	1.91	0.41	-0.10	4.15	0.35	1.80	2.14
1.32	-0.02	0.86	2.30	0.26	2.01	1.87	0.41	-0.14	4.15	0.24	1.76	2.14
1.31	-0.05	0.80	2.21	0.15	1.99	1.83	0.40	-0.18	4.15	0.13	1.72	2.14
1.29	-0.09	0.74	2.12	0.04	1.96	1.79	0.40	-0.23	4.15	0.03	1.68	2.13
1.28	-0.12	0.67	2.03	-0.06	1.94	1.76	0.40	-0.27	4.15	-0.08	1.63	2.13
1.27	-0.16	0.61	1.94	-0.16	1.91	1.72	0.40	-0.31	4.16	-0.19	1.59	2.12
1.26	-0.19	0.55	1.86	-0.26	1.89	1.68	0.40	-0.36	4.16	-0.29	1.54	2.12
1.24	-0.23	0.49	1.77	-0.36	1.87	1.64	0.40	-0.40	4.16	-0.40	1.48	2.11
1.23	-0.26	0.43	1.68	-0.45	1.85	1.60	0.40	-0.44	4.17	-0.50	1.43	2.11
1.23	-0.29	0.37	1.60	-0.54	1.82	1.57	0.40	-0.48	4.18	-0.61	1.37	2.10
1.22	-0.32	0.31	1.51	-0.63	1.80	1.53	0.40	-0.52	4.19	-0.71	1.31	2.10
1.21	-0.36	0.25	1.43	-0.71	1.78	1.50	0.40	-0.56	4.20	-0.81	1.24	2.10
1.21	-0.39	0.20	1.35	-0.79	1.76	1.46	0.41	-0.60	4.21	-0.92	1.17	2.09
1.21	-0.42	0.14	1.26	-0.87	1.74	1.43	0.41	-0.64	4.23	-1.02	1.10	2.09
1.21	-0.45	0.08	1.18	-0.94	1.72	1.39	0.41	-0.68	4.24	-1.12	1.02	2.08
1.21	-0.47	0.03	1.10	-1.01	1.70	1.36	0.42	-0.72	4.26	-1.22	0.94	2.08
1.21	-0.50	-0.03	1.02	-1.07	1.69	1.33	0.43	-0.75	4.29	-1.32	0.86	2.07
1.22	-0.53	-0.08	0.94	-1.13	1.67	1.30	0.43	-0.79	4.31	-1.42	0.78	2.07
1.23	-0.55	-0.13	0.86	-1.19	1.66	1.27	0.44	-0.82	4.33	-1.51	0.70	2.07
1.24	-0.58	-0.18	0.78	-1.24	1.64	1.24	0.45	-0.86	4.36	-1.61	0.62	2.06
1.25	-0.60	-0.24	0.71	-1.28	1.63	1.21	0.46	-0.89	4.39	-1.71	0.53	2.06
1.26	-0.62	-0.29	0.63	-1.33	1.62	1.19	0.47	-0.92	4.43	-1.80	0.45	2.06
1.28	-0.65	-0.33	0.56	-1.37	1.61	1.16	0.48	-0.95	4.46	-1.89	0.37	2.05
1.30	-0.67	-0.38	0.48	-1.40	1.60	1.14		-0.98	4.50	-1.99	0.29	2.05
1.33	-0.69	-0.43	0.41	-1.43	1.59	1.11		-1.01	4.54	-2.08	0.21	2.05
1.35	-0.70	-0.47	0.34	-1.46	1.58	1.09		-1.03	4.58	-2.17	0.13	2.05
1.38	-0.72	-0.52	0.27	-1.48	1.58	1.07		-1.06	4.63	-2.25	0.05	2.04
1.41	-0.74	-0.56	0.20	-1.51	1.57	1.05		-1.08	4.67	-2.34		2.04
1.45	-0.75	-0.60	0.13	-1.53	1.57	1.03		-1.11	4.72	-2.43		2.04
1.48	-0.76	-0.64	0.07	-1.54	1.56	1.01		-1.13	4.77	-2.51		2.04
1.52	-0.78	-0.68	0.00	-1.56	1.56	1.00		-1.15	4.82	-2.60		2.04
1.56	-0.79	-0.72	-0.06	-1.57	1.56	0.98		-1.17	4.87	-2.68		2.04
1.61	-0.80	-0.76	-0.12	-1.58	1.56	0.97		-1.19	4.93	-2.76		2.04
1.66	-0.81	-0.79	-0.19	-1.60	1.56	0.96		-1.21	4.99	-2.84		2.04
1.71			-0.25	-1.61	1.57	0.94		-1.22	5.05	-2.92		2.04
1.76			-0.31	-1.61	1.57	0.93		-1.24	5.10	-3.00		2.04
1.82	-			-1.62	1.58	0.92		-1.25	5.17	-3.08		2.05



St. Croix, US Virgin Islands

VW24 Minus Average Backgroun d Fit (°C)	VW25 Minus Average Backgroun d Fit (°C)	VW27 Minus Average Backgroun d Fit (°C)	VW29 Minus Average Backgroun d Fit (°C)	VW30 Minus Average Backgroun d Fit (°C)	VW31 Minus Average Backgroun d Fit (°C)	VW32 Minus Average Backgroun d Fit (°C)	VW34 Minus Average Backgroun d Fit (°C)	VW35 Minus Average Backgroun d Fit (°C)	VW4 Minus Average Backgroun d Fit (°C)	VW5 Minus Average Backgroun d Fit (°C)	VW6 Minus Average Backgroun d Fit (°C)	VW7 Minus Average Backgroun d Fit (°C)
1.88					-	0.92		-1.26	5.23			2.05
1.94								-1.27	5.29	-		2.06
2.01								-1.28	5.36			2.06
2.07								-1.29		-		2.07
2.14								-1.30		-		2.07
2.22								-1.31		-		2.08
2.29								-1.31		-		2.09
2.37								-1.32		-		2.10
2.45								-1.32		-		2.11
2.53								-1.32				2.12
2.61								-1.33				2.13
2.70								-1.33				2.15
2.78								-1.33				2.16
2.87								-1.33				
2.96								-1.32				
3.05								-1.32				
3.15								-1.32				
3.24								-1.32				
3.34								-1.31				
3.44												
3.53												
3.63												
3.73												
3.83												
3.93												

Notes



^{-- =} Temperature profile predictions were limited to the approximate depths where data was collected.

ft = foot or feet

[°]C = degrees centigrade

Unsaturated Zone Temperature Gradient Calculation Draft Phase 2 Natural Source Zone Depletion Assessment Report St. Croix Alumina Site

St. Croix, U.S. Virgin Islands

Well	Upper Temp. (°C)	Lower Temp. (°C)	Upper Elevation ¹	Lower Elevation ¹	ΔΤ/ΔΖ	Calculated Heat Flux (q _H)	R _{NSZD} (grams/m²/day)	Polygon Area (m²)	grams/day	
VW2	29.66	30.35	25.00	1.00	0.029	0.102	0.185	4,622	855.6	
VW4		Not Applica	able - reverse	temperature {	gradient		0	17,643	0	
VW5	27.77	28.2	5.00	1.00	0.108	0.381	0.692	4,934	3,415.3	
VW6	27.57	29.6	28.00	1.00	0.075	0.266	0.484	8,672	4,198.3	
VW7	29.53	29.9	30.00	1.00	0.013	0.045	0.082	12,039	989.0	
VW13	29.57	30.76	20.00	1.00	0.063	0.222	0.403	7,175	2,893.6	
VW13B	28.22	30.34	31.00	1.00	0.071	0.250	0.455	1,081	491.9	
VW14	27.13	29.69	33.00	1.00	0.080	0.283	0.515	5,230	2,694.1	
VW15	28.67	31.46	43.00	8.00	0.080	0.282	0.513	14,515	7,450.3	
VW16		No	t Applicable - I	•	0	3732	0			
VW18	27.9	29.85	36.00	1.00 0.056 0.197		0.197	0.359	16,851	6,045.3	
VW20	27.01	30.61	37.00	1.00	0.100	0.354	0.644	5,593	3,601.4	
VW20B	30.03	31.22	25.00	1.00	0.050	0.176	0.319	2,109	673.3	
VW21B	27.45	29.55	37.00	1.00	0.058	0.207	0.376	16,531	6,209.3	
VW23	27.56	30.25	29.00	1.00	0.096	0.340	0.619	10,254	6,343.2	
VW24	28.89	29.1	16.00	1.00	0.014	0.050	0.090	19,070	1,719.1	
VW25	26.53	27.8	35.00	1.00	0.037	0.132	0.241	7,560	1,818.3	
VW27	26.55	28.73	35.00	1.00	0.064	0.227	0.413	10,286	4,246.7	
VW29	27.0	30.22	37.00	1.00	0.090	0.320	0.581	6,604	3,838.9	
VW30	26.5	28.22	20.00	1.00	0.093	0.328	0.596	29,384	17,526.4	
VW31	29.2	29.81	25.00	1.00	0.027	0.094	0.172	37,884	6,505.0	
VW32	28.13	29.7	39.00	1.00	0.041	0.146	0.266	48,505	12,904.0	
VW34	28.13	28.16	10.00	1.00	0.003	0.012	0.021	7,488	160.7	
VW35	N	Not Applicable - Lower temperature than background					0	19,825	0	

Total 94,580.0

 LNAPL Density (g/mL)
 0.777

 Total Rate (mL/day)
 121,724.53

 Total Rate (gallons/day)
 32.1562138

Total Rate (gallons/year) 11,737

Notes:

 ${\bf 1.} \ {\bf Elevations} \ {\bf are} \ {\bf in} \ {\bf units} \ {\bf of} \ {\bf feet} \ {\bf relative} \ {\bf to} \ {\bf the} \ {\bf elevation} \ {\bf of} \ {\bf the} \ {\bf groundwater} \ {\bf table}.$

°C = degrees Celsius

g = grams

LNAPL = light non-aqueous phase liquid

m² = square meters

mL = milliliter

NSZD = natural source zone depletion

Temp. = Temperature

 $\Delta T/\Delta Z$ = temperature change divided by elevation change

 q_H = heat flux



Unsaturated Zone Gas Gradient Curve Fitting and Background Subtraction Draft Phase 2 Natural Source Zone Depletion Assessment Report St. Croix Alumina Site

St. Croix, U.S.	Virgin Islands
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llaimh:		Methan	e (% Vol)			Carbon Dio	xide (% Vol)		Oxygen (% Vol)				
Height above water table (ft)	Background SG1	SG2	SG3	SG4	Background SG1	SG2	SG3	SG4	Background SG1	SG2	SG3	SG4	
1.00	0.00	12.21	1.48	15.04	7.50	12.48	5.70	19.45	12.72	3.52	12.43	0.00	
2.00	0.03	11.65	1.36	13.94	7.39	12.00	5.71	18.77	12.85	4.14	12.28	0.00	
3.00	0.08	11.08	1.23	12.85	7.28	11.53	5.73	18.09	12.97	4.75	12.13	0.00	
4.00	0.13	10.52	1.11	11.77	7.17	11.05	5.74	17.41	13.10	5.37	11.98	0.29	
5.00	0.17	9.95	0.99	10.70	7.06	10.58	5.75	16.72	13.22	5.99	11.83	0.66	
6.00	0.22	9.39	0.87	9.65	6.96	10.11	5.77	16.02	13.35	6.61	11.69	1.08	
7.00	0.27	8.82	0.76	8.63	6.85	9.63	5.77	15.31	13.47	7.22	11.56	1.57	
8.00	0.32	8.26	0.65	7.63	6.74	9.16	5.78	14.59	13.60	7.84	11.44	2.13	
9.00	0.37	7.69	0.55	6.66	6.63	8.68	5.78	13.86	13.73	8.46	11.33	2.77	
10.00	0.41	7.13	0.46	5.72	6.52	8.21	5.78	13.11	13.85	9.07	11.23	3.49	
11.00	0.46	6.56	0.37	4.82	6.41	7.73	5.78	12.35	13.98	9.69	11.14	4.31	
12.00	0.50	6.00	0.28	3.96	6.30	7.26	5.77	11.58	14.10	10.31	11.07	5.23	
13.00	0.54	5.43	0.21	3.13	6.20	6.79	5.76	10.79	14.23	10.93	11.01	6.23	
14.00	0.59	4.87	0.14	2.33	6.09	6.31	5.74	9.99	14.36	11.54	10.96	7.32	
15.00	0.63	4.30	0.08	1.56	5.98	5.84	5.72	9.18	14.48	12.16	10.94	8.50	
16.00	0.67	3.74	0.02	0.83	5.87	5.36	5.70	8.35	14.61	12.78	10.92	9.76	
17.00	0.70	3.17	0.00	0.12	5.76	4.89	5.67	7.51	14.73	13.39	10.92	11.10	
18.00	0.74	2.61	0.00	0.00	5.65	4.42	5.63	6.67	14.86	14.01	10.94	12.50	
19.00	0.78	2.04	0.00	0.00	5.55	3.94	5.60	5.81	14.99	14.63	10.97	13.96	
20.00	0.81	1.48	0.00	0.00	5.44	3.47	5.55	4.95	15.11	15.25	11.01	15.45	
21.00	0.84	0.91	0.00	0.00	5.33	2.99	5.51	4.09	15.24	15.86	11.07	16.97	
22.00	0.87	0.35	0.00	0.00	5.22	2.52	5.46	3.22	15.36	16.48	11.14	18.50	
23.00	0.90	0.00	0.00	0.00	5.11	2.04	5.41	2.35	15.49	17.10	11.22	20.03	
24.00	0.92	0.00	0.00	0.00	5.00	1.57	5.35	1.48	15.62	17.72	11.31	21.57	
25.00	0.94	0.00	0.00	0.00	4.89	1.10	5.29	0.62	15.74	18.33	11.41	23.10	
26.00	0.97	0.00	0.00		4.79	0.62	5.23		15.87	18.95	11.51		
27.00	0.99	0.00	0.00		4.68	0.15	5.17		15.99	19.57	11.63		
28.00	1.00	0.00	0.00		4.57	0.00	5.11		16.12	20.18	11.74		
29.00	1.02	0.00	0.00		4.46	0.00	5.04		16.25	20.80	11.86		
30.00	1.04	0.00	0.00		4.35	0.00	4.98		16.37	21.42	11.99		

Notes

-- = Gas profile predictions were limited to the approximate depths where data was collected.

ft = foot or feet

% Vol = percent by volume



Unsaturated Zone Gas Gradient Calculation - Oxygen

Draft Phase 2 Natural Source Zone Depletion Assessment Report

St. Croix Alumina Site

St. Croix, U.S. Virgin Islands

Location	Designation	C _{o2} Upper (ppm)	C _{o2} Lower (ppm)	C _{O2} Upper (mg O ₂ /m ³)	C _{O2} Lower (mg O ₂ /m ³)	ΔZ (m)	$\Delta C_{02}/\Delta Z$	Background Corrected ΔC _{CO2} /ΔZ (g CO ₂ /m ³)	R_{NSZD} (grams $O_2/m^2/day$)	Area (m²)	grams _{octadecane} /day	Octadecane Density (g/mL)	I NS7D Rate	NSZD Rate (gallons/da y)		NSZD Rate (gallons/ac re/year)
MMX/SG-1	Background	163,700	127,200	214,134	166,389	8.84	5.40	na	na	na	na	0.777	na			na
VW20/SG-2	Source	214,200	35,200	280,192	46,045	8.84	26.49	21.09	0.80	114646.67	26576	0.777	34203	9	3300	116
VW31/SG-3	Source	119,900	109,200	156,840	142,843	3.96	3.53	-1.87	-0.07	114646.67	0	0.777	0	0	0	0
VW13/SG-4	Source	231,000	0.0	302,168	0.0	6.71	45.06	39.66	1.51	114646.67	49982	0.777	64327	17	6207	219

Notes: O₂ Diffusion Coefficient <u>Total</u> 9507

^a Polygon area is historical extent of LNAPL (343,940 m²) divided by three.

g = grams

m² = square meters

mL = milliliter

na = not used is subsequent calculations

NSZD = natural source zone depletion

ppm = parts per million (% volume * 10,000)

R_{NSZD} = Natural source zone depletion rate

 $\Delta C/\Delta Z$ = concentration change divided by elevation change

 $2C_{18}H_{38} + 55O_2 \rightarrow 36CO_2 + 38H_2O$ O_2 (g/mol) C₁₈H₃₈ (g/mol)

Stoichiometric Octadecane:O2 ratio

Air filled porosity (cm³/cm³)

O₂ molecular diffusion coefficient

O₂ diffusion coeffect (m²/s)(Millington and Quirk, 1961)

Total porosity (cm³/cm³)

0.098

0.15

0.21

4.40E-07

32.00

254.50 Utilization ratio (g_{octadecne}/g_{O2}) 0.2892

C₀₂ = Oxygen concentration

 $C_{18}H_{38}$ = octadecane

cm³ = cubic centimeters

 CO_2 = carbon dioxide

 $H_2O = water$

LNAPL = light non-aqueous phase liquid

m = meters

m³ = cubic meters

m³m = meters cubed per meter

mg = milligrams

mol = mole

O₂ = oxygen

s = second

 ΔZ = elevation change

Millington, R.J. and Quirk, J.P., 1961. Permeability of porous solids. Transactions of the Faraday Society, 57, pp.1200-1207.



Table A-11

Unsaturated Zone Gas Gradient Calculation - Carbon Dioxide Draft Phase 2 Natural Source Zone Depletion Assessment Report

St. Croix Alumina Site

St. Croix, U.S. Virgin Islands

Well	Designation	C _{co2} Upper (ppm)	C _{co2} Lower (ppm)	C _{CO2} Upper (mg CO ₂ /m ³)	C _{CO2} Lower (mg CO ₂ /m ³)	ΔZ (m)	ΔC _{CO2} /ΔZ (g CO ₂ /m ³ m)	Background Corrected $\Delta C_{CO2}/\Delta Z$ (g CO_2/m^3)	R _{NSZD} (grams CO ₂ /m ² /day)	(111)	grams _{octadecane} /day	Octadecan e Density (g/mL)	NICZD Data	NSZD Rate (gallons/day)	NSZD Rate (gallons/year)	NSZD Rate (gallons/acre/ year)
MMX/SG-1	Background	43,500	75,000	78,258	134,927	8.84	6.41	na	na	na	na	0.777	na	na	na	na
VW20/SG-2	Source	0.0	124,800	0.0	224,519	8.23	27.28	20.87	0.60	114646.67	22261	0.777	28650	8	2764	98
VW31/SG-3	Source	49,800	57,800	89,592	103,984	5.79	2.49	-3.93	-0.11	114646.67	0	0.777	0	0	0	0
VW13/SG-4	Source	6,200	194,500	11,154	349,911	7.32	46.31	39.90	1.16	114646.67	42556	0.777	54769	14	5285	187

Notes: CO₂ Diffusion Coefficient **Total** 8049

^a Polygon area is historical extent of LNAPL (343,940 m²) divided by three.

 $\Delta C/\Delta Z$ = concentration change divided by elevation change g = grams

Total porosity (cm³/cm³) CO₂ molecular diffusion coefficient 0.15 0.16

m² = square meters

mL = milliliter

CO₂ diffusion coeffect (m²/s)(Millington and Quirk, 1961)

3.35E-07

0.3213

0.098

na = not used is subsequent calculations NSZD = natural source zone depletion

Stoichiometric Octadecane:CO2 ratio

ppm = parts per million (% volume * 10,000)

 $2C_{18}H_{38} + 55O_2 \rightarrow 36CO_2 + 38H_2O$

Air filled porosity (cm³/cm³)

R_{NSZD} = Natural source zone depletion rate

CO₂ (g/mol) 44.01 C₁₈H₃₈ (g/mol) 254.50

Utilization ratio ($g_{\text{octane}}/g_{\text{CO2}}$)

 $C_{18}H_{38}$ = octadecane

C_{CO2} = carbon dioxide concentration

cm³ = cubic centimeters

 CO_2 = carbon dioxide

 H_2O = water

LNAPL = light non-aqueous phase liquid

m = meters

m³ = cubic meters

m³m = meters cubed per meter

mg = milligrams

mol = mole

s = seconds

 ΔZ = elevation change

Millington, R.J. and Quirk, J.P., 1961. Permeability of porous solids. Transactions of the Faraday Society, 57, pp.1200-1207.



Table A-12 Unsaturated Zone DCC Calculations Draft Phase 2 Natural Source Zone Depletion Assessment Report St. Croix Alumina Site

St. Croix, U.S. Virgin Islands

		Raw	Data			Background Cor	rected Minimum	Background Corrected Average		Background Corrected Maximum		Area	Max. NSZD Rate		Av. NSZD Rate		Min. NSZD Rate	
Location	Ground Cover	Date	Start Time	Dry CH ₄ Flux (Linear fit)	Dry CO₂ Flux (Linear fit)	Dry CH₄ Flux (Linear fit)	Dry CO ₂ Flux (Linear fit)	Dry CH ₄ Flux (Linear fit)	Dry CO ₂ Flux (Linear fit)	Dry CH₄ Flux (Linear fit)	Dry CO ₂ Flux (Linear fit)	Polygon Area	CH₄	NSZD Rate CO ₂ (Linear fit)	CH₄	CO ₂	· NSZD Rate CH ₄ (Linear fit)	NSZD Rate - CO ₂ (Linear fit)
			Eastern (Local) Time	nmol·m ⁻² s ⁻¹	μmol·m ⁻² s ⁻¹	nmol·m ⁻² s ⁻¹	μmol·m ⁻² s ⁻¹	nmol·m ⁻² s ⁻¹	μmol·m ⁻² s ⁻¹	nmol·m ⁻² s ⁻¹	μmol·m ⁻² s ⁻¹	m²			_		gallons/pol ygon/year	gallons/poly gon/year
Background																		
DCC-BKG-1	Cleared Scrub	4/26/2022	10:45:48	-0.72	0.70													
DCC-BKG-VW9R	Cleared Scrub	4/26/2022	10:25:42	-0.66	1.49													
DCC-1	Cleared Scrub	4/26/2022	10:14:07	-0.63	1.04													
DCC-2	Cleared Scrub	4/26/2022	11:06:59	-0.38	0.98													
DCC-4	Cleared Scrub	4/26/2022	10:34:29	-0.63	1.13													
DCC-BKG-MMX-2	Cleared Scrub	4/26/2022	13:03:21	-0.91	0.64													
Minimum				-0.91	0.64													
Average				-0.65	1.00													
Maximum				-0.38	1.49										-			
•		•	•			•			•	•	•		•	•		•	•	
DCC-3	Grass	4/26/2022	10:57:24	-0.88	0.82													
DCC-3-1	Grass	4/28/2022	09:34:04	-0.78	1.43													
DCC-3-2	Grass	4/28/2022	12:38:03	-0.89	0.73													
DCC-3-3	Grass	4/28/2022	15:00:49	-0.83	0.64													
DCC-VW7	Grass	4/26/2022	09:45:36	-0.41	1.31													
DCC-BKG-2	Grass	4/26/2022	13:38:30	-1.01	1.86													
Minimum				-1.01	0.64													
Average				-0.80	1.13													
Maximum				-0.41	1.86													
		•	T				,		T	_		r	1				1	_
DCC-5	Gravel	4/26/2022	11:43:57	-1.20	0.64													
DCC-5	Gravel	4/28/2022	10:33:54	-1.10	0.64													
Minimum				-1.20	0.64													
Average				-1.15	0.64													
Maximum				-1.10	0.64													
DCC MANAG	Managed Tr. C	4/20/2022	00:42:20	2.27	4.24		1 1		T	T		I	ı	1		1	ı	
DCC-MM9	Managed Turf	4/28/2022	09:12:20	-2.27	4.21													



Table A-12 **Unsaturated Zone DCC Calculations** Draft Phase 2 Natural Source Zone Depletion Assessment Report St. Croix Alumina Site St. Croix, U.S. Virgin Islands

Start Time							•				1		ı			1		T		
Search Common C		Raw Data						Background Corrected Minimum Background Correct			ted Average Background Corrected Maximum			Max. NSZD Rate		Av. NSZD Rate N		Min. N	lin. NSZD Rate	
Source Area	Location	Ground Cover	Date	Start Time		l								CH₄	CO ₂	CH ₄	CO ₂	CH₄	CO ₂ (Linear	
DCC-25				Eastern (Local) Time	nmol·m ⁻² s ⁻¹	μmol·m ⁻² s ⁻¹	nmol·m ⁻² s ⁻¹	μmol·m ⁻² s ⁻¹	nmol·m ⁻² s ⁻¹	μmol·m ⁻² s ⁻¹	nmol·m ⁻² s ⁻¹	μmol·m ⁻² s ⁻¹	m²		_	_				
DCC-2900F Asphalt APJ7/2072 11.94-81 0.28 4.88 0.88 4.19 0.57 3.88 0.09 5.34 4.97. 0.37 1.97 0.72 1.749 0.00 0.	Source Area										_		•	•		•	•			
DCC-WW15 Asphalt 478/0002 1311/11 0.61 13.00 0.31 13.00 0.55 18.00 0.22 17.51 6038 0.22 19144 0.03 9987	DCC-25	Asphalt	4/27/2022	10:58:54	-0.28	4.45	0.64	3.81	0.38	3.46	0.10	2.97	4976	0.38	1737	0.23	1575	0.06	1351	
DEC-WIS-15	DCC-25DUP	Asphalt	4/27/2022	11:04:41	-0.29	4.83	0.63	4.19	0.37	3.83	0.09	3.34	4976	0.37	1907	0.22	1746	0.05	1521	
DCC-WISDUP Asphalt A72/7022 145222 -0.51 17.32 0.40 16.68 0.44 16.12 -0.17 15.83 6038 0.28 9218 0.10 9021	DCC-VW15	Asphalt	4/26/2022	11:17:11	-0.61	19.00	0.31	18.36	0.05	18.00	-0.23	17.51	6038	0.22	10144	0.03	9947	0	9675	
DCC-15 Chewed Scub 42/7/2022 1115-52 -0.58 ref 0.33 0 0.07 0 -0.21 0 4255 0.17 0 0.08 0.74 92 0 DCC-16 Chewed Scub 42/7/2022 1011:34 -0.21 1.87 0.70 1.23 0.44 0.87 0.17 0.38 5933 0.50 688 0.31 473 0.70 0.08 0.08 0.08 0.09 0.05 0.03 0.08 0.09 0.05 0.08 0.09 0.05 0.08 0.09 0.05 0.05 0.08 0.05 0.05 0.08 0.05	DCC-VW15-1	Asphalt	4/28/2022	09:24:51	-0.54	17.34	0.37	16.70	0.11	16.35	-0.16	15.86	6038	0.27	9231	0.08	9034	0	8762	
DCC-16 Cleared Strub Aff7/2022 1303320 0.58 1.16 1.30 0.52 1.04 0.17 0.76 -0.92 3933 0.92 285 0.74 92 0.75	DCC-VW15DUP	Asphalt	4/28/2022	14:52:22	-0.51	17.32	0.40	16.68	0.14	16.32	-0.13	15.83	6038	0.29	9218	0.10	9021	0	8749	
DCC-16 Cleared Strub 478/5/002 1011-134 0.21 1.87 0.70 1.23 0.44 0.87 0.17 0.38 9933 0.50 666 0.31 473 0.00 0.0	DCC-15	Cleared Scrub	4/27/2022	11:15:42	-0.58	nd	0.33	0	0.07	0	-0.21	0	4265	0.17	0	0.04	0	0	0	
DEC-7 Cleared Setub 476/2002 13474-0 0.66 1.53 0.26 0.89 0.00 0.33 0.28 0.04 7892 0.24 641 0.00 334 0.65	DCC-16	Cleared Scrub	4/27/2022	13:03:20	0.38	1.16	1.30	0.52	1.04	0.17	0.76	-0.32	5933	0.92	285	0.74	92	0.54	0	
DCC-8 Cleared Scrub A1/6/D022 14-58-85 -1-0.8 0-68 -0.12 0.00 -0.18 -0.16 -0.65 -0.65 -0.65 5133 0.00 0 -0.23 0	DCC-16	Cleared Scrub	4/28/2022	10:11:34	-0.21	1.87	0.70	1.23	0.44	0.87	0.17	0.38	5933	0.50	666	0.31	473	0.12	205	
DCC-10	DCC-7	Cleared Scrub	4/26/2022	13:47:40	-0.66	1.53	0.26	0.89	0.00	0.53	-0.28	0.04	7892	0.24	641	0.00	384	0	28	
DEC:11 Gress 4786/2022 15:23:45 O-67 1.95 O-34 1.31 O.13 O-82 O-27 O-09 S-072 O-20 G-07 O-08 379 D-25 D-25 D-25 G-25 O-25 D-25 D-	DCC-8	Cleared Scrub	4/26/2022	14:58:35	-1.03	0.64	-0.12	0.00	-0.38	-0.36	-0.65	-0.85	5135	0.00	0	-0.23	0	0	0	
DCC-12 Grass 4785/2022 1555842 -0.41 2.21 0.61 1.57 0.39 1.08 0.00 0.35 10482 0.76 1593 0.50 1032 DCC-13 Grass 4787/2022 132351 0.95 1.11 0.07 0.47 0.15 0.02 0.54 0.04 0.07 0.00	DCC-10	Grass	4/26/2022	16:05:23	-0.69	2.48	0.32	1.84	0.11	1.35	-0.29	0.63	6875	0.26	1160	0.09	851	0	395	
DCC13	DCC-11	Grass	4/26/2022	15:23:45	-0.67	1.95	0.34	1.31	0.13	0.82	-0.27	0.09	5072	0.20	607	0.08	379	0	42	
DCC-17	DCC-12	Grass	4/26/2022	15:55:42	-0.41	2.21	0.61	1.57	0.39	1.08	0.00	0.35	10482	0.76	1503	0.50	1032	0	336	
DCC-19 Grass 4/27/2022 13:14:49 -9.52 1.69 0.49 1.05 0.28 0.56 -0.11 -0.17 0 0.00 0 0 0 0 0 0 0	DCC-13	Grass	4/26/2022	11:35:02	-0.22	nd	0.79	0	0.58	0	0.18	0	4522	0.43	0	0.31	0	0.10	0	
DCC-20	DCC-17	Grass	4/27/2022			1.11	0.07	0.47	-0.15	-0.02	-0.54	-0.74	0	0.00	0	0	0	0	0	
DCC-22 Grass 4/27/2022 10:50:10 -0.61 cd 0.40 0 0.19 0 -0.20 0 3795 0.18 0 0.09 0	DCC-19	Grass	4/27/2022	13:14:49	-0.52	1.69	0.49	1.05	0.28	0.56	-0.11	-0.17	0	0.00	0	0	0	0	0	
DCC-23 Grass 4/27/2022 10:24:57 -1:29 2.49 -0.28 1.85 -0.49 1.156 -0.88 0.63 3681 0.00 622 -0.21 457 DCC-29 Grass 4/27/2022 09:00:00 -0.51 0.65 0.50 0.01 0.29 -0.49 0.11 -1:21 4172 0.25 2 0.14 0 DCC-6 Grass 4/26/2022 13:26:51 -0.95 2.15 0.06 1.51 -0.15 1.02 0.54 0.29 -0.49 0.11 -1:21 4172 0.25 2 0.14 0 DCC-6 Grass 4/28/2022 10:45:10 -0.51 1.52 0.50 0.88 0.29 0.39 0.01 0.33 7604 0.46 615 0.27 274 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25	DCC-20	Grass	4/27/2022	08:41:58	na	1.94	0	1.30	0	0.81	0	0.08	8503	0.00	1012	0	631	0	66	
DCC-93	-		+	•		1	0.40	1	0.19		-0.20			+		1	!	0	0	
DCC-93	DCC-23	Grass	4/27/2022	10:24:57	-1.29	2.49	-0.28	1.85	-0.49	1.36	-0.88	0.63	3681	0.00	622	-0.21	457	0	212	
DCC-6 Grass 4/26/2022 13:26:51 0.95 2.15 0.06 1.51 0.15 1.02 0.54 0.29 7604 0.06 1051 0.14 7.10		Grass		09:00:05			0.50		0.29		-0.11	-1.21	4172	0.25		0.14	0	0	0	
DCC-92 Grass 4/27/2022 07:46:44 -0.58 1.42 0.43 0.78 0.22 0.29 -0.17 -0.44 7604 0.40 540 0.20 199	DCC-6	Grass	4/26/2022	13:26:51		2.15	0.06	1.51	-0.15	1.02	-0.54	0.29	7604	0.06	1051	-0.14	710	0	205	
DCC-92 Grass 4/27/2022 07:46:44 -0.58 1.42 0.43 0.78 0.22 0.29 -0.17 -0.44 7604 0.40 540 0.20 199	DCC-6	Grass	4/28/2022	10:45:10	-0.51	1.52	0.50	0.88	0.29	0.39	-0.10	-0.33	7604	0.46	615	0.27	274	0	0	
DCC-9 Grass 4/26/2022 15:42:59 -0.18 1.90 0.83 1.26 0.62 0.77 0.23 0.04 7810 0.78 900 0.58 549 0 0 0.58 549 0 0 0.58 549 0 0 0.58 549 0 0 0.58 549 0 0 0.58 549 0 0 0.58 549 0 0 0.58 549 0 0 0.58 549 0 0 0.58 549 0 0 0.58 549 0 0 0.58 549 0 0 0.58 549 0 0 0.58 549 0 0 0.58 549 0 0 0.58 549 0 0 0.58 549 0 0 0.58 549 0 0 0.58 549 0 0 0 0.58 549 0 0 0 0.58 549 0 0 0 0.58 549 0 0 0 0.58 549 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0				•	1		0.43	0.78	0.22	0.29	-0.17	-0.44	7604	0.40		1	199	0	0	
DCC-WI3							ļ							+				0.21	31	
DCC-VW13 Grass 4/27/2022 11:44:28 -0.11 2.33 0.90 1.69 0.69 1.20 0.30 0.48 3897 0.42 604 0.32 429 0				•			+				1			+				0.31	657	
DCC-W13B Grass 4/28/2022 09:55:30 na 2.07 0 1.43 0 0.94 0 0.21 2823 0.00 368 0 242			+		1		+				+			+				0.14	170	
DCC-W13B-DUP Grass 4/28/2022 10:01:57 na 2.09 0 1.45 0 0.96 0 0.24 2823 0.00 376 0 249					 		+									1		0	54	
DCC-VW14 Grass 4/27/2022 11:35:22 -0.75 1.68 0.26 1.04 0.05 0.55 -0.35 -0.18 4604 0.14 438 0.03 231 DCC-VW17 Grass 4/27/2022 10:40:36 -0.19 1.67 0.82 1.03 0.61 0.54 0.22 -0.18 2583 0.25 244 0.19 128 0 DCC-VW18 Grass 4/27/2022 10:09:48 -1.28 8.00 -0.27 7.36 -0.48 6.87 -0.87 6.15 2360 0.00 1590 -0.14 1484 DCC-VW18-1 Grass 4/28/2022 08:59:21 -1.14 7.62 -0.12 6.98 -0.34 6.49 -0.73 5.76 2360 0.00 1590 -0.14 1484 DCC-VW18-2 Grass 4/28/2022 14:42:14 -1.16 5.90 -0.15 5.26 -0.36 4.77 -0.75 4.05 2360 0.00 1137 -0.10					na	 	0		0		0			+		0	!	0	61	
DCC-W17 Grass 4/27/2022 10:40:36 -0.19 1.67 0.82 1.03 0.61 0.54 0.22 -0.18 2583 0.25 244 0.19 128 0 DCC-VW18 Grass 4/27/2022 10:09:48 -1.28 8.00 -0.27 7.36 -0.48 6.87 -0.87 6.15 2360 0.00 1590 -0.14 1484 DCC-VW18-1 Grass 4/28/2022 08:59:21 -1.14 7.62 -0.12 6.98 -0.34 6.49 -0.73 5.76 2360 0.00 1507 -0.09 1401 DCC-VW18-2 Grass 4/28/2022 12:26:49 -1.10 7.25 -0.09 6.61 -0.30 6.12 -0.70 5.40 2360 0.00 1428 -0.09 1322 DCC-VW18-3 Grass 4/28/2022 14:42:14 -1.16 5.90 -0.15 5.26 -0.36 4.77 -0.75 4.05 2360 0.00 1137 -0.10 <td></td> <td></td> <td></td> <td>•</td> <td></td> <td></td> <td>0.26</td> <td></td> <td>0.05</td> <td></td> <td></td> <td></td> <td></td> <td>+</td> <td></td> <td></td> <td>!</td> <td>0</td> <td>0</td>				•			0.26		0.05					+			!	0	0	
DCC-VW18 Grass 4/27/2022 10:09:48 -1.28 8.00 -0.27 7.36 -0.48 6.87 -0.87 6.15 2360 0.00 1590 -0.14 1484 DCC-VW18-1 Grass 4/28/2022 08:59:21 -1.14 7.62 -0.12 6.98 -0.34 6.49 -0.73 5.76 2360 0.00 1507 -0.09 1401 DCC-VW18-2 Grass 4/28/2022 12:26:49 -1.10 7.25 -0.09 6.61 -0.30 6.12 -0.70 5.40 2360 0.00 1428 -0.09 1322 DCC-VW18-3 Grass 4/28/2022 14:42:14 -1.16 5.90 -0.15 5.26 -0.36 4.77 -0.75 4.05 2360 0.00 1137 -0.10 1031 DCC-VW18DUP Grass 4/27/2022 10:16:22 -1.33 8.20 -0.31 7.56 -0.52 7.07 -0.92 6.34 2360 0.00 1632 -0.15							ļ							+				0.07	0	
DCC-VW18-1 Grass 4/28/2022 08:59:21 -1.14 7.62 -0.12 6.98 -0.34 6.49 -0.73 5.76 2360 0.00 1507 -0.09 1401 DCC-VW18-2 Grass 4/28/2022 12:26:49 -1.10 7.25 -0.09 6.61 -0.30 6.12 -0.70 5.40 2360 0.00 1428 -0.09 1322 DCC-VW18-3 Grass 4/28/2022 14:42:14 -1.16 5.90 -0.15 5.26 -0.36 4.77 -0.75 4.05 2360 0.00 1137 -0.10 1031 DCC-VW18-0P Grass 4/27/2022 10:16:22 -1.33 8.20 -0.31 7.56 -0.52 7.07 -0.92 6.34 2360 0.00 1632 -0.15 1526 DCC-VW19 Grass 4/26/2022 11:26:44 -0.64 1.26 0.37 0.62 0.16 0.13 -0.23 -0.60 5930 0.26 335 0.11 <t< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td>+</td><td></td><td></td><td></td><td></td><td></td><td></td><td>+</td><td></td><td></td><td></td><td>0</td><td>1328</td></t<>							+							+				0	1328	
DCC-VW18-2 Grass 4/28/2022 12:26:49 -1.10 7.25 -0.09 6.61 -0.30 6.12 -0.70 5.40 2360 0.00 1428 -0.09 1322 DCC-VW18-3 Grass 4/28/2022 14:42:14 -1.16 5.90 -0.15 5.26 -0.36 4.77 -0.75 4.05 2360 0.00 1137 -0.10 1031 DCC-VW18DUP Grass 4/27/2022 10:16:22 -1.33 8.20 -0.31 7.56 -0.52 7.07 -0.92 6.34 2360 0.00 1632 -0.15 1526 DCC-VW19 Grass 4/26/2022 11:26:44 -0.64 1.26 0.37 0.62 0.16 0.13 -0.23 -0.60 5930 0.26 335 0.11 68 DCC-VW2 Grass 4/26/2022 09:55:36 -1.11 2.43 -0.09 1.79 -0.30 1.30 -0.70 0.57 6971 0.00 1141 -0.25 828											+			+				0	1244	
DCC-VW18-3 Grass 4/28/2022 14:42:14 -1.16 5.90 -0.15 5.26 -0.36 4.77 -0.75 4.05 2360 0.00 1137 -0.10 1031 DCC-VW18DUP Grass 4/27/2022 10:16:22 -1.33 8.20 -0.31 7.56 -0.52 7.07 -0.92 6.34 2360 0.00 1632 -0.15 1526 DCC-VW19 Grass 4/26/2022 11:26:44 -0.64 1.26 0.37 0.62 0.16 0.13 -0.23 -0.60 5930 0.26 335 0.11 68 DCC-VW2 Grass 4/26/2022 09:55:36 -1.11 2.43 -0.09 1.79 -0.30 1.30 -0.70 0.57 6971 0.00 1141 -0.25 828 DCC-VW20 Grass 4/27/2022 09:30:08 -0.59 4.76 0.42 4.12 0.21 3.63 -0.19 2.90 5415 0.24 2053 0.10 1810																		0	1166	
DCC-VW18DUP Grass 4/27/2022 10:16:22 -1.33 8.20 -0.31 7.56 -0.52 7.07 -0.92 6.34 2360 0.00 1632 -0.15 1526 DCC-VW19 Grass 4/26/2022 11:26:44 -0.64 1.26 0.37 0.62 0.16 0.13 -0.23 -0.60 5930 0.26 335 0.11 68 DCC-VW2 Grass 4/26/2022 09:55:36 -1.11 2.43 -0.09 1.79 -0.30 1.30 -0.70 0.57 6971 0.00 1141 -0.25 828 DCC-VW20 Grass 4/27/2022 09:30:08 -0.59 4.76 0.42 4.12 0.21 3.63 -0.19 2.90 5415 0.27 2042 0.13 1799 DCC-VW20DUP Grass 4/27/2022 09:36:29 -0.64 4.78 0.37 4.14 0.16 3.65 -0.24 2.93 5415 0.24 2053 0.10 1810				•	1		+	1			+			+		1	!	0	874	
DCC-VW19 Grass 4/26/2022 11:26:44 -0.64 1.26 0.37 0.62 0.16 0.13 -0.23 -0.60 5930 0.26 335 0.11 68 DCC-VW2 Grass 4/26/2022 09:55:36 -1.11 2.43 -0.09 1.79 -0.30 1.30 -0.70 0.57 6971 0.00 1141 -0.25 828 DCC-VW20 Grass 4/27/2022 09:30:08 -0.59 4.76 0.42 4.12 0.21 3.63 -0.19 2.90 5415 0.27 2042 0.13 1799 DCC-VW20DUP Grass 4/27/2022 09:36:29 -0.64 4.78 0.37 4.14 0.16 3.65 -0.24 2.93 5415 0.24 2053 0.10 1810 DCC-VW21 Grass 4/27/2022 08:51:16 -0.61 1.99 0.40 1.35 0.19 0.86 -0.20 0.14 5221 0.25 647 0.12 412							+							+				0	1370	
DCC-VW2 Grass 4/26/2022 09:55:36 -1.11 2.43 -0.09 1.79 -0.30 1.30 -0.70 0.57 6971 0.00 1141 -0.25 828 DCC-VW20 Grass 4/27/2022 09:30:08 -0.59 4.76 0.42 4.12 0.21 3.63 -0.19 2.90 5415 0.27 2042 0.13 1799 DCC-VW20DUP Grass 4/27/2022 09:36:29 -0.64 4.78 0.37 4.14 0.16 3.65 -0.24 2.93 5415 0.24 2053 0.10 1810 DCC-VW21 Grass 4/27/2022 08:51:16 -0.61 1.99 0.40 1.35 0.19 0.86 -0.20 0.14 5221 0.25 647 0.12 412														+				0	0	
DCC-VW20 Grass 4/27/2022 09:30:08 -0.59 4.76 0.42 4.12 0.21 3.63 -0.19 2.90 5415 0.27 2042 0.13 1799 DCC-VW20DUP Grass 4/27/2022 09:36:29 -0.64 4.78 0.37 4.14 0.16 3.65 -0.24 2.93 5415 0.24 2053 0.10 1810 DCC-VW21 Grass 4/27/2022 08:51:16 -0.61 1.99 0.40 1.35 0.19 0.86 -0.20 0.14 5221 0.25 647 0.12 412														+				0	365	
DCC-VW20DUP Grass 4/27/2022 09:36:29 -0.64 4.78 0.37 4.14 0.16 3.65 -0.24 2.93 5415 0.24 2053 0.10 1810 DCC-VW21 Grass 4/27/2022 08:51:16 -0.61 1.99 0.40 1.35 0.19 0.86 -0.20 0.14 5221 0.25 647 0.12 412				•			ļ				+			+				0	1439	
DCC-VW21 Grass 4/27/2022 08:51:16 -0.61 1.99 0.40 1.35 0.19 0.86 -0.20 0.14 5221 0.25 647 0.12 412				•			+				1			+		1		0	1450	
																		0	65	
DOC 88820 O1003 T LI LOCK 14.03.01 T.T. C.O1 O.OO 1.01 O.OO T.U.U. O.OO T.U.U. O.OO				•	ł	1	+				+			+				0	80	
						 					+			+				0	0	
DCC-VW24 Grass 4/26/2022 13:07:22 -0:71 Nu 0.30 U 0.09 U -0:30 U 0139 0.22 U 0.07 U 0.07 U 0.09 U 0.				•				_		_								0	0	



Table A-12 **Unsaturated Zone DCC Calculations Draft Phase 2 Natural Source Zone Depletion Assessment Report** St. Croix Alumina Site

St. Croix, U.S. Virgin Islands

		Raw	Data			Background Cor	rected Minimum	Background Co	Background Corrected Average		Background Corrected Maximum		Max. NSZD Rate		Av. NSZD Rate		Min. NSZD Rate	
Location	Ground Cover	Date	Start Time	Dry CH ₄ Flux (Linear fit)	Dry CO ₂ Flux (Linear fit)	Dry CH₄ Flux (Linear fit)	Dry CO ₂ Flux (Linear fit)	Dry CH₄ Flux (Linear fit)	Dry CO ₂ Flux (Linear fit)	Dry CH₄ Flux (Linear fit)	Dry CO ₂ Flux (Linear fit)	Polygon Area	CH ₄	CO2	NSZD Rate CH ₄ (Linear fit)	CO ₂	CH₄	· NSZD Rate - CO ₂ (Linear fit)
			Eastern (Local) Time	nmol·m ⁻² s ⁻¹	μmol·m ⁻² s ⁻¹	nmol·m ⁻² s ⁻¹	μmol·m ⁻² s ⁻¹	nmol·m ⁻² s ⁻¹	μmol·m ⁻² s ⁻¹	nmol·m ⁻² s ⁻¹	μmol·m ⁻² s ⁻¹	m ²			gallons/pol ygon/year	-		gallons/poly gon/year
DCC-VW25	Grass	4/27/2022	08:02:44	-0.16	1.47	0.85	0.83	0.64	0.34	0.24	-0.39	6875	0.70	520	0.53	211	0.20	0
DCC-VW26	Grass	4/27/2022	08:23:48	na	1.31	0	0.67	0	0.18	0	-0.55	15905	0.00	972	0	258	0	0
DCC-VW28	Grass	4/27/2022	08:16:00	na	1.32	0	0.68	0	0.19	0	-0.54	6677	0.00	414	0	114	0	0
DCC-VW31	Grass	4/26/2022	16:24:56	-0.10	1.19	0.91	0.55	0.70	0.06	0.31	-0.66	22952	2.51	1160	1.93	130	0.85	0
DCC-VW31B	Grass	4/28/2022	11:06:14	-0.85	3.76	0.16	3.12	-0.05	2.63	-0.45	1.90	14995	0.28	4279	-0.10	3606	0	2610
DCC-VW31BDUP	Grass	4/28/2022	11:12:38	-0.90	3.95	0.11	3.31	-0.10	2.82	-0.49	2.10	14995	0.20	4549	-0.17	3876	0	2880
DCC-VW-32	Grass	4/26/2022	15:33:31	-0.73	7.88	0.28	7.24	0.07	6.75	-0.33	6.02	6728	0.22	4455	0.05	4153	0	3707
DCC-VW35	Grass	4/26/2022	15:15:34	-1.89	1.34	-0.88	0.70	-1.09	0.21	-1.48	-0.52	6276	0.00	400	-0.82	118	0	0
DCC-VW38	Grass	4/27/2022	08:32:47	-0.39	1.89	0.62	1.25	0.41	0.76	0.02	0.03	9797	0.73	1120	0.48	680	0.02	29
DCC-VW4	Grass	4/26/2022	08:28:40	-0.68	2.06	0.34	1.42	0.12	0.93	-0.27	0.21	12241	0.49	1592	0.18	1043	0	230
DCC-VW4-2	Grass	4/26/2022	13:14:43	-0.80	1.30	0.21	0.66	0.00	0.17	-0.40	-0.56	12241	0.30	736	0	186	0	0
DCC-VW4-3	Grass	4/26/2022	16:40:27	-0.75	1.68	0.26	1.04	0.05	0.55	-0.34	-0.17	12241	0.38	1171	0.07	621	0	0
DCC-VW4DUP	Grass	4/26/2022	08:34:18	-0.69	2.08	0.33	1.44	0.12	0.95	-0.28	0.22	12241	0.48	1611	0.17	1061	0	249
DCC-VW5	Grass	4/26/2022	10:04:21	-0.74	2.39	0.27	1.75	0.06	1.26	-0.33	0.54	4862	0.16	780	0.04	562	0	239
DCC-VW5	Grass	4/28/2022	09:44:32	-0.68	2.90	0.33	2.26	0.12	1.77	-0.28	1.04	4862	0.19	1005	0.07	787	0	464
DCC-VW6	Grass	4/27/2022	11:26:29	na	2.19	0	1.55	0	1.06	0	0.33	5467	0.00	775	0.00	529	0	166
DCC-14	Gravel	4/27/2022	09:49:06	-0.19	0.85	1.00	0.21	0.96	0.21	0.91	0.21	5064	0.61	99	0.58	99	0.55	99
DCC-18	Gravel	4/27/2022	13:23:53	-0.46	1.53	0.73	0.89	0.68	0.89	0.64	0.89	2103	0.18	171	0.17	171	0	171
DCC-21	Gravel	4/27/2022	09:10:21	na	0.89	0	0.25	0	0.25	0	0.25	5159	0.00	117	0	117	0	117
DCC-24	Gravel	4/27/2022	10:32:27	-1.28	3.35	-0.08	2.71	-0.13	2.71	-0.18	2.71	3213	0.00	796	-0.05	796	0	796
DCC-24	Gravel	4/28/2022	10:23:01	-0.92	2.23	0.28	1.59	0.23	1.59	0.18	1.59	3213	0.11	468	0.09	468	0	468
DCC-VW30	Gravel	4/27/2022	09:59:11	-1.80	2.03	-0.60	1.39	-0.65	1.39	-0.70	1.39	6907	0.00	878	-0.54	878	0	878

Total Gallons per Year 14 47,914 7 36,903 3 24,831

(uses average of duplicate locations)

Locations outside area of historical LNAPL are assigned a polygon area of zero, thus, are not considered to contribute to mass losses.

Not detected nd

Not applicable, correlation coefficient too low na $nmol \cdot m^{-2} s^{-1}$ nanomole per meter square per second μmol·m⁻²s⁻¹ micromole per meter square per second

1.80 Non detect - detection limit used in calculations.

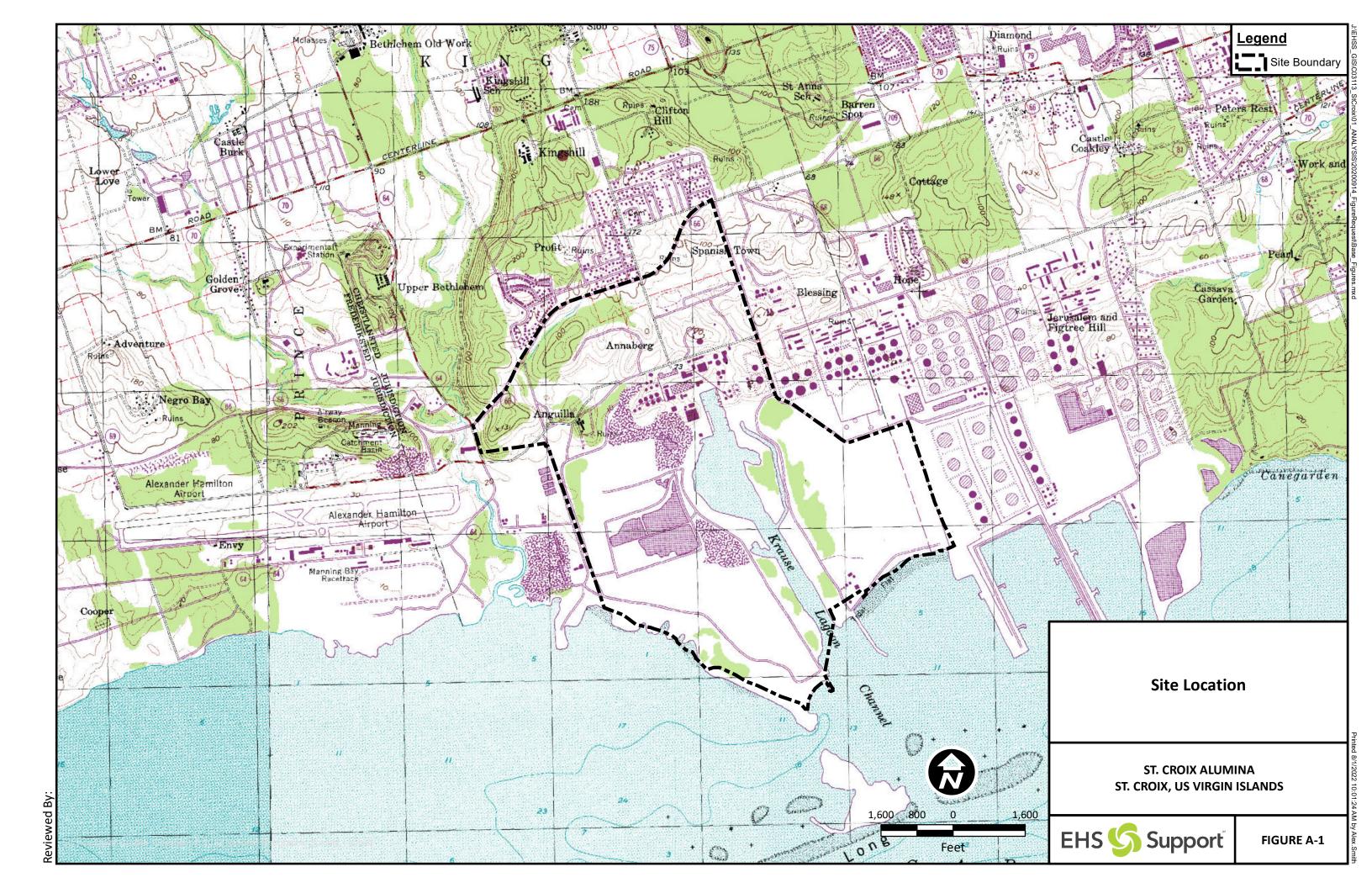
-1.35 Negative values following background correction - zero value used in mass loss calculations. CO_2 = carbon dioxide CO₂ = carbon dioxide

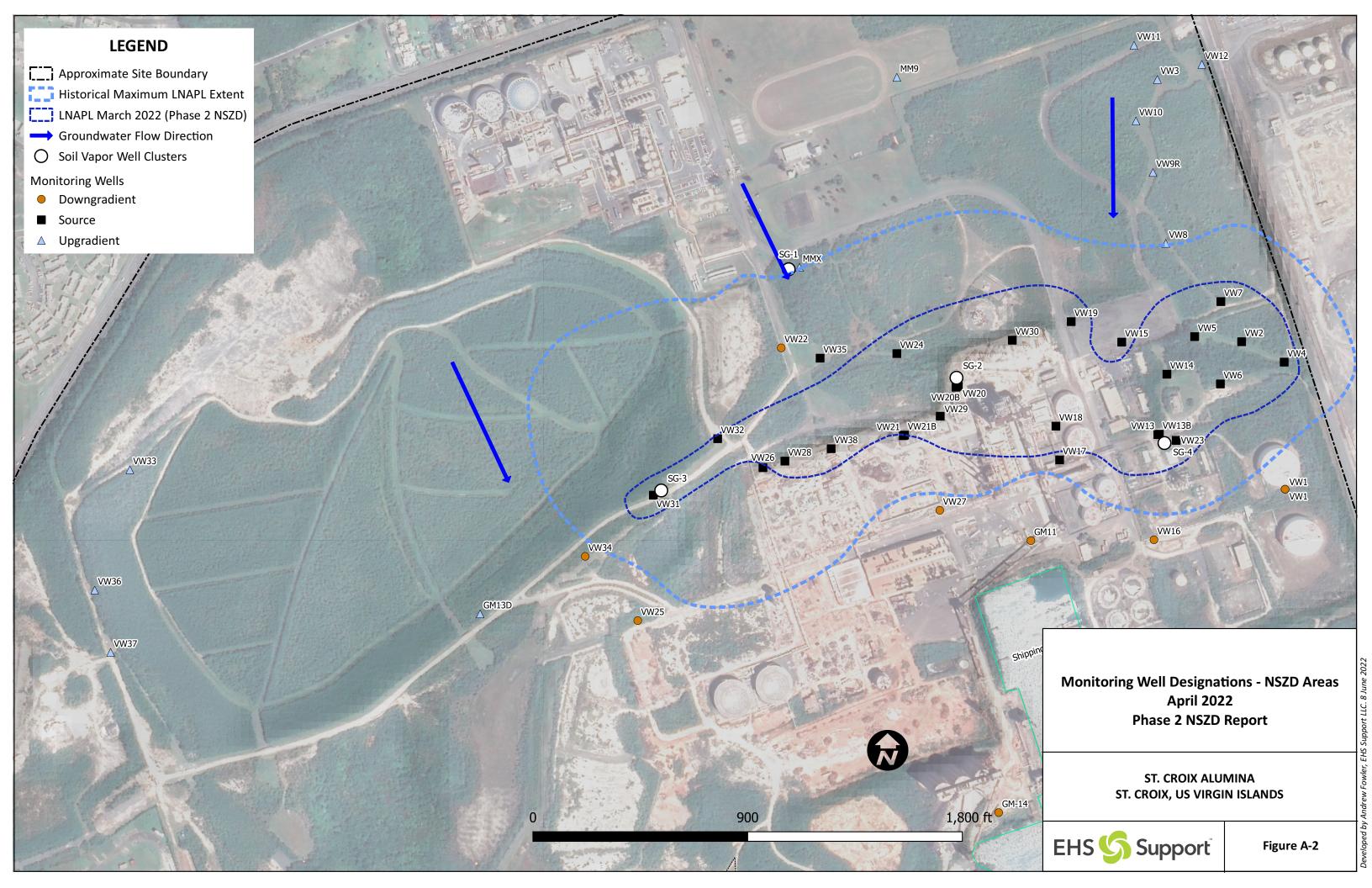
d = day DUP = duplicate g = grams

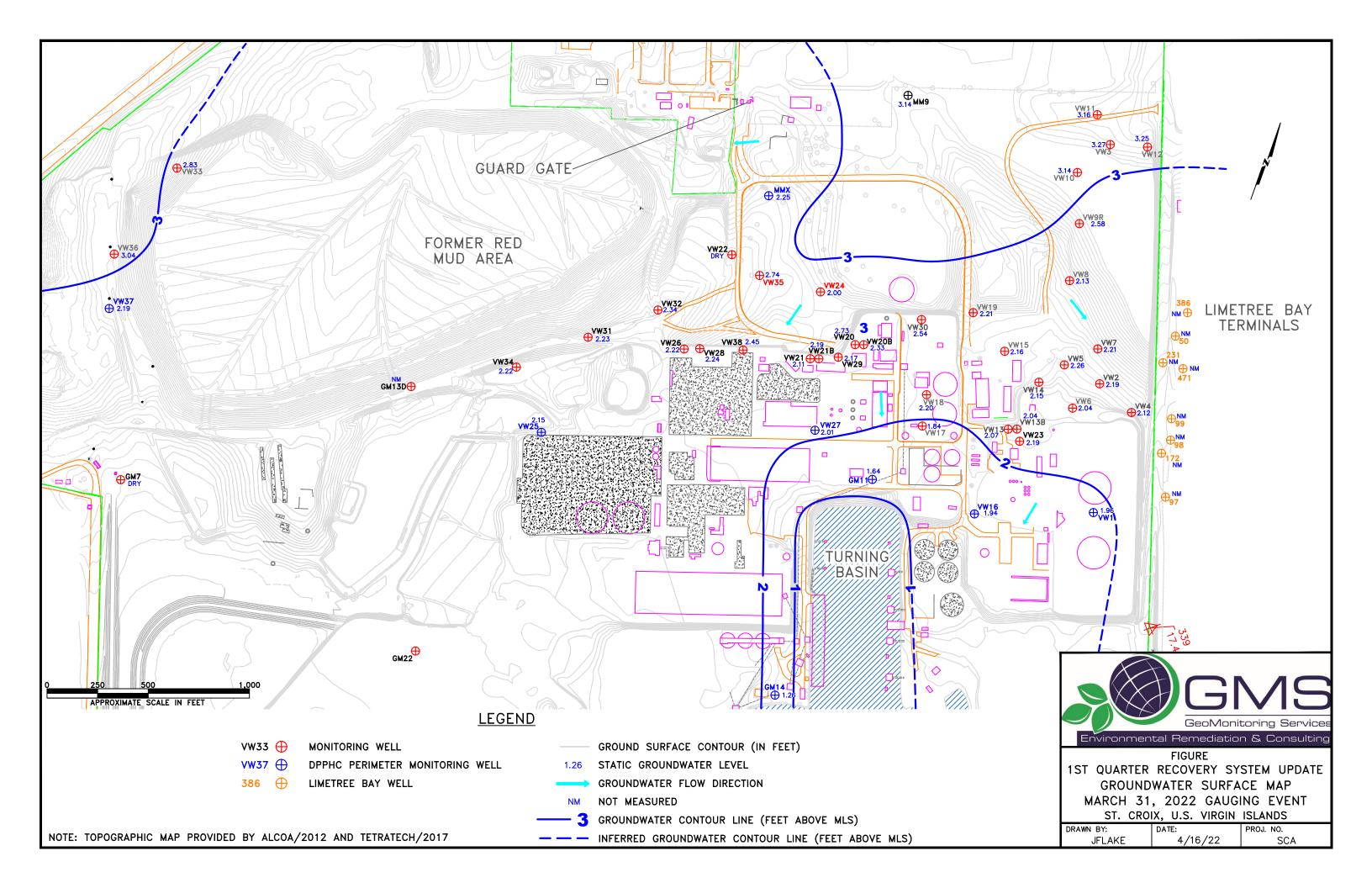


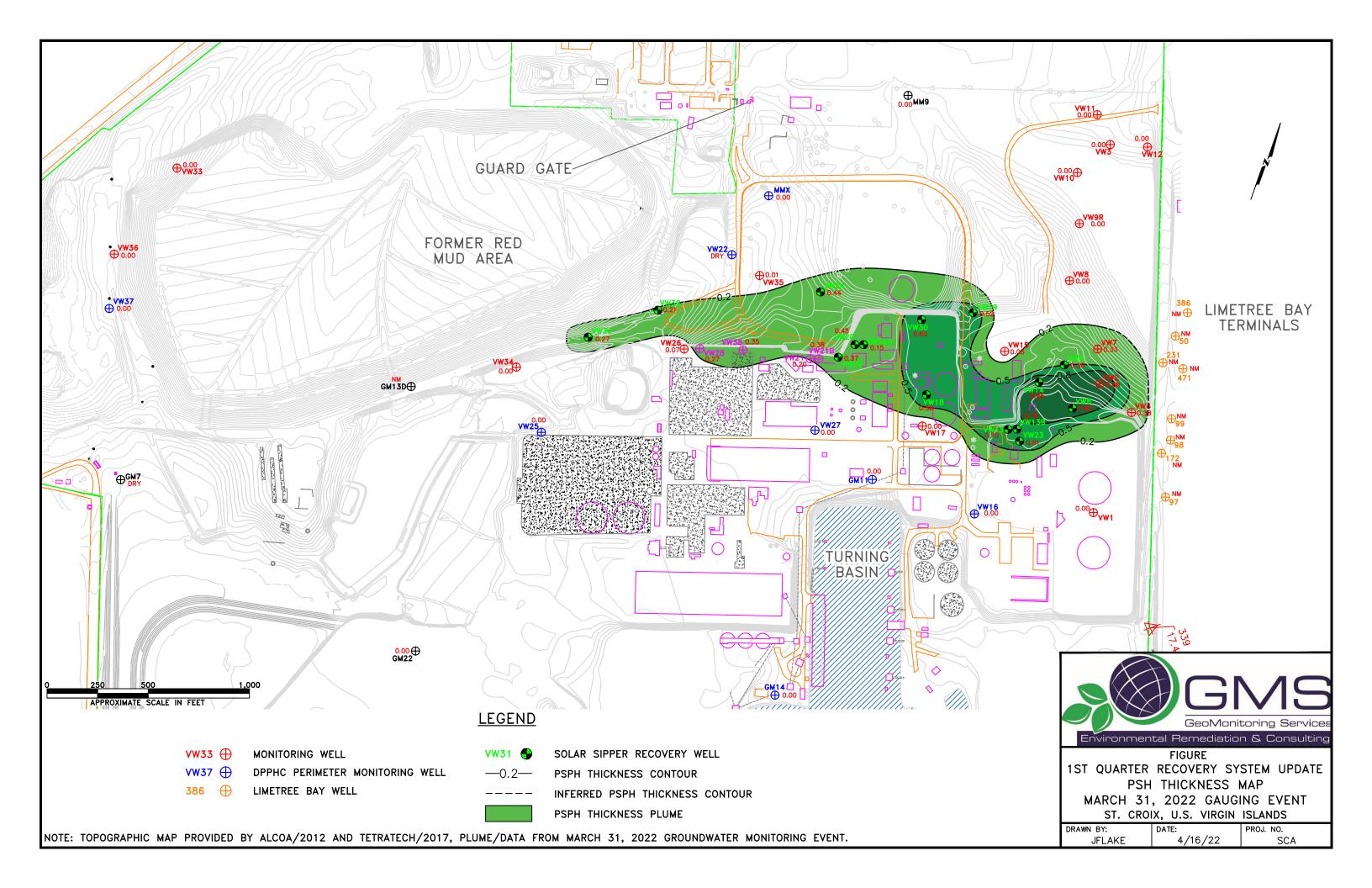


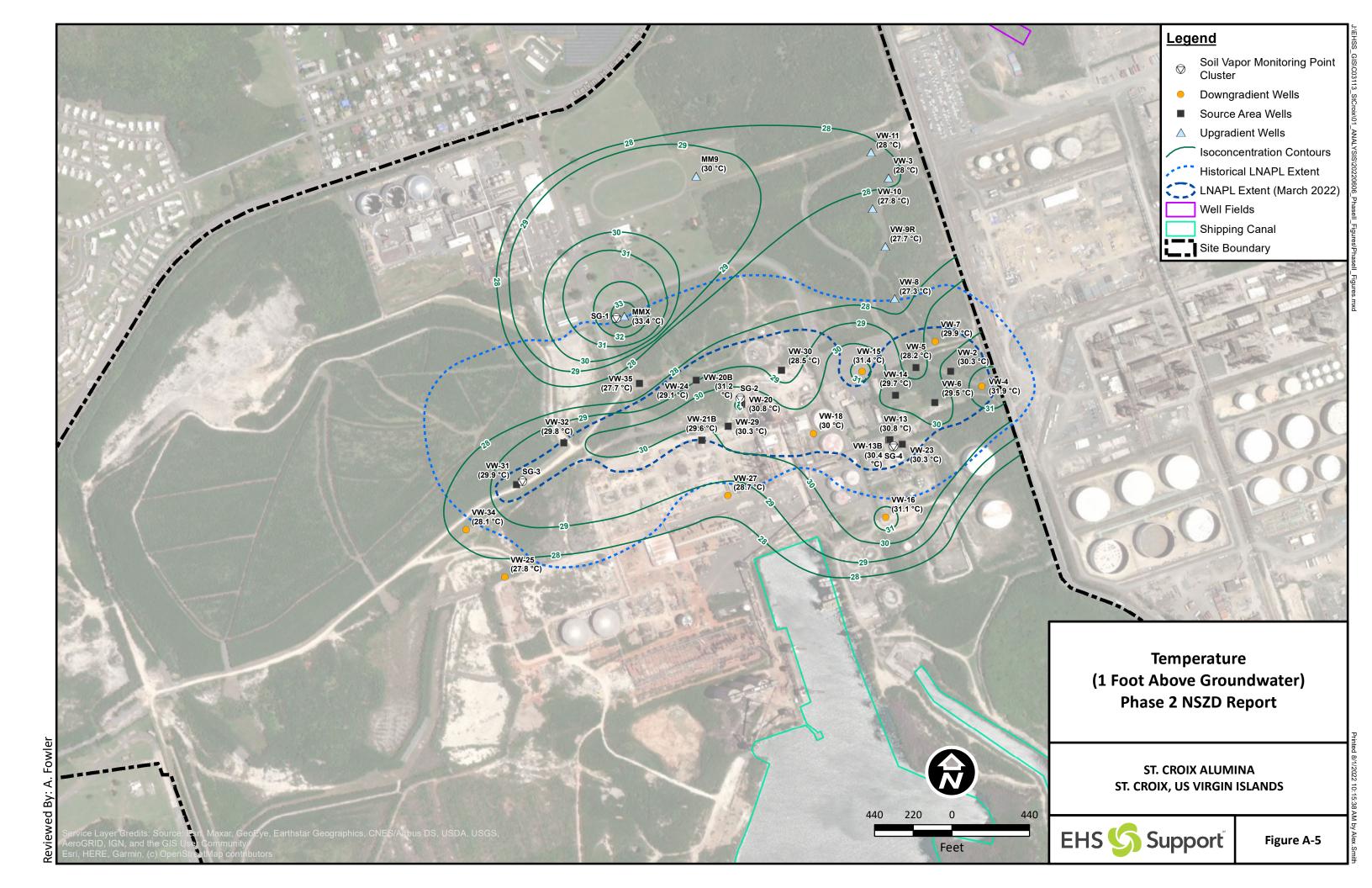
Figures

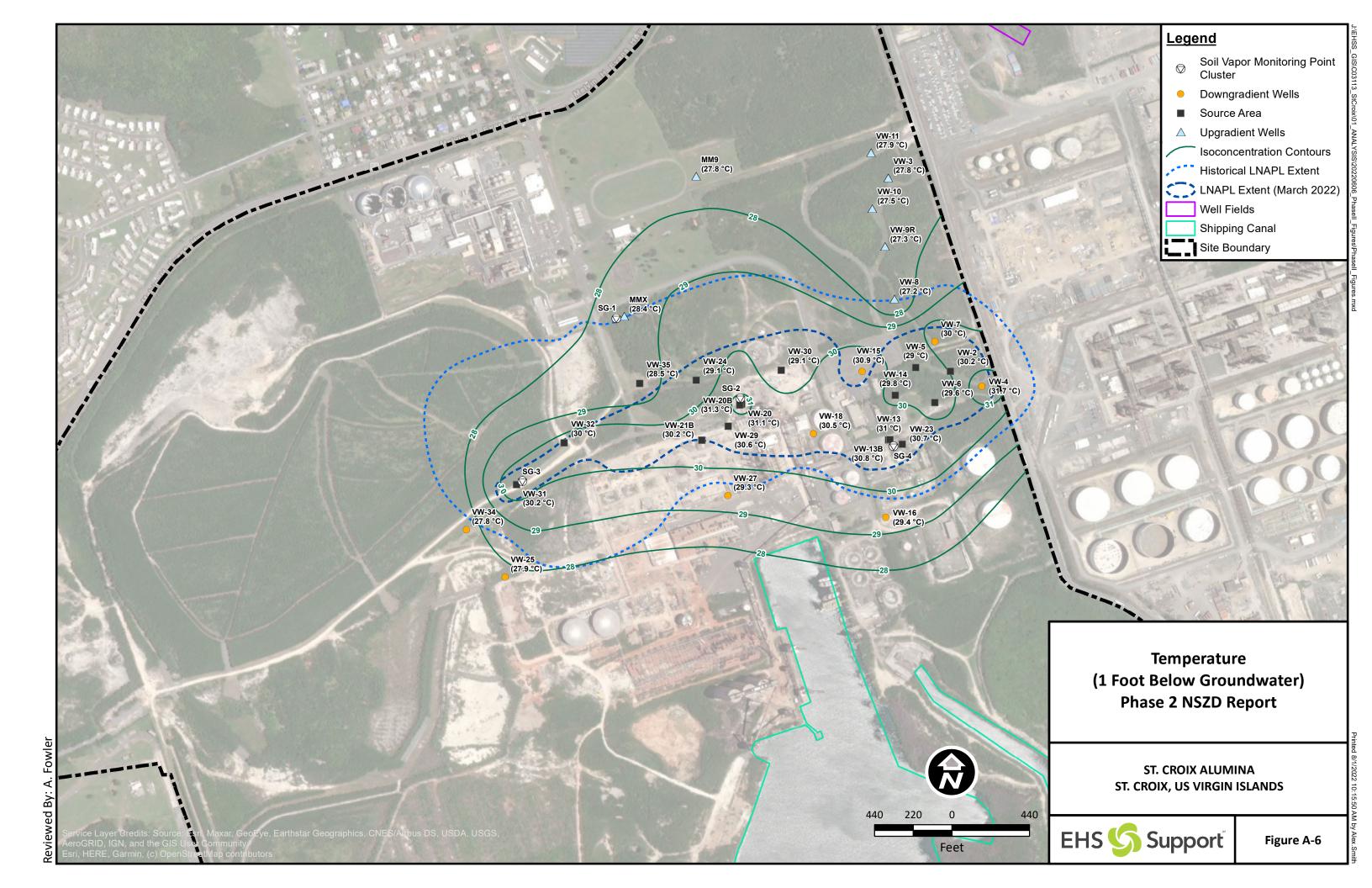


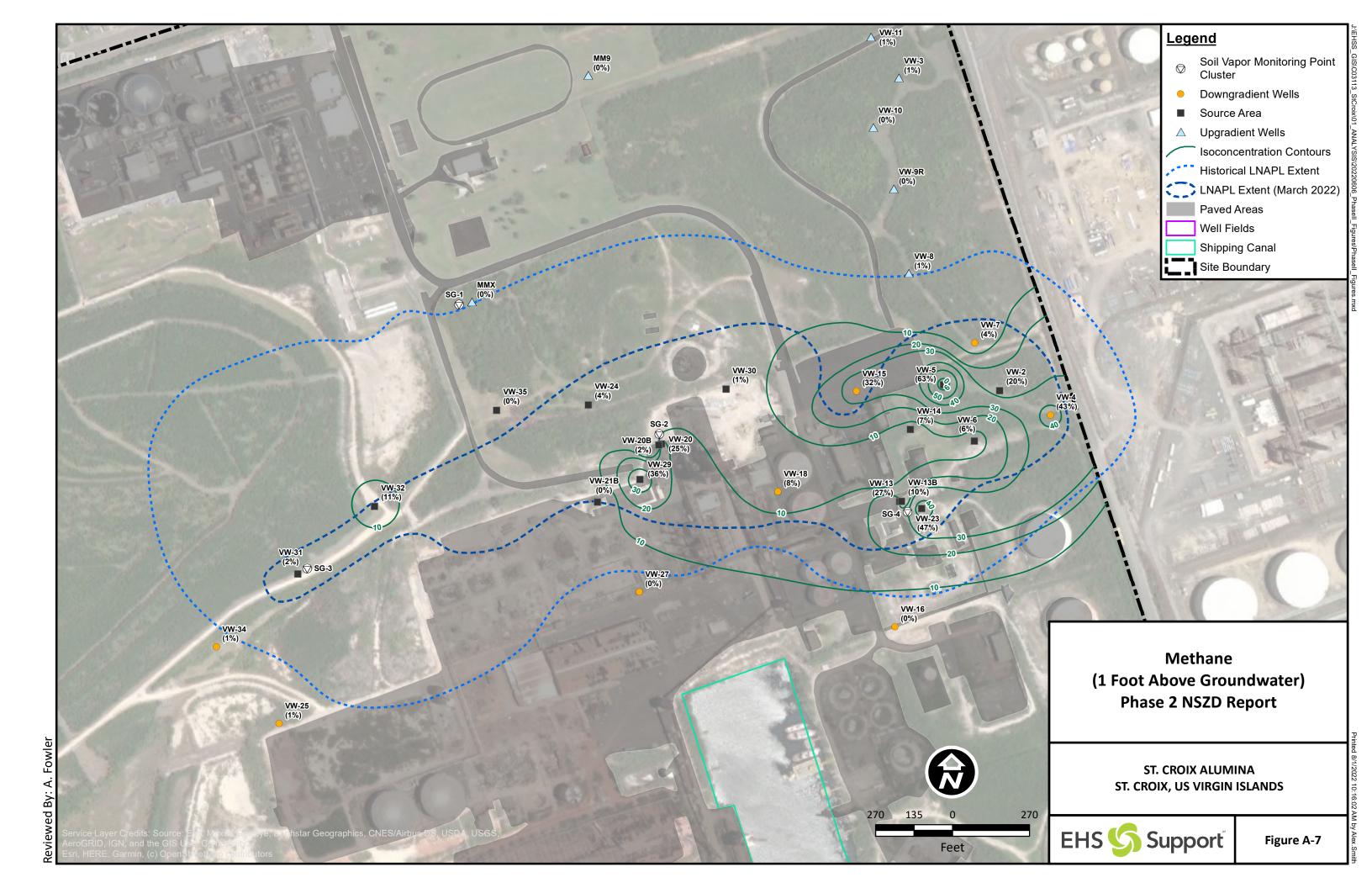


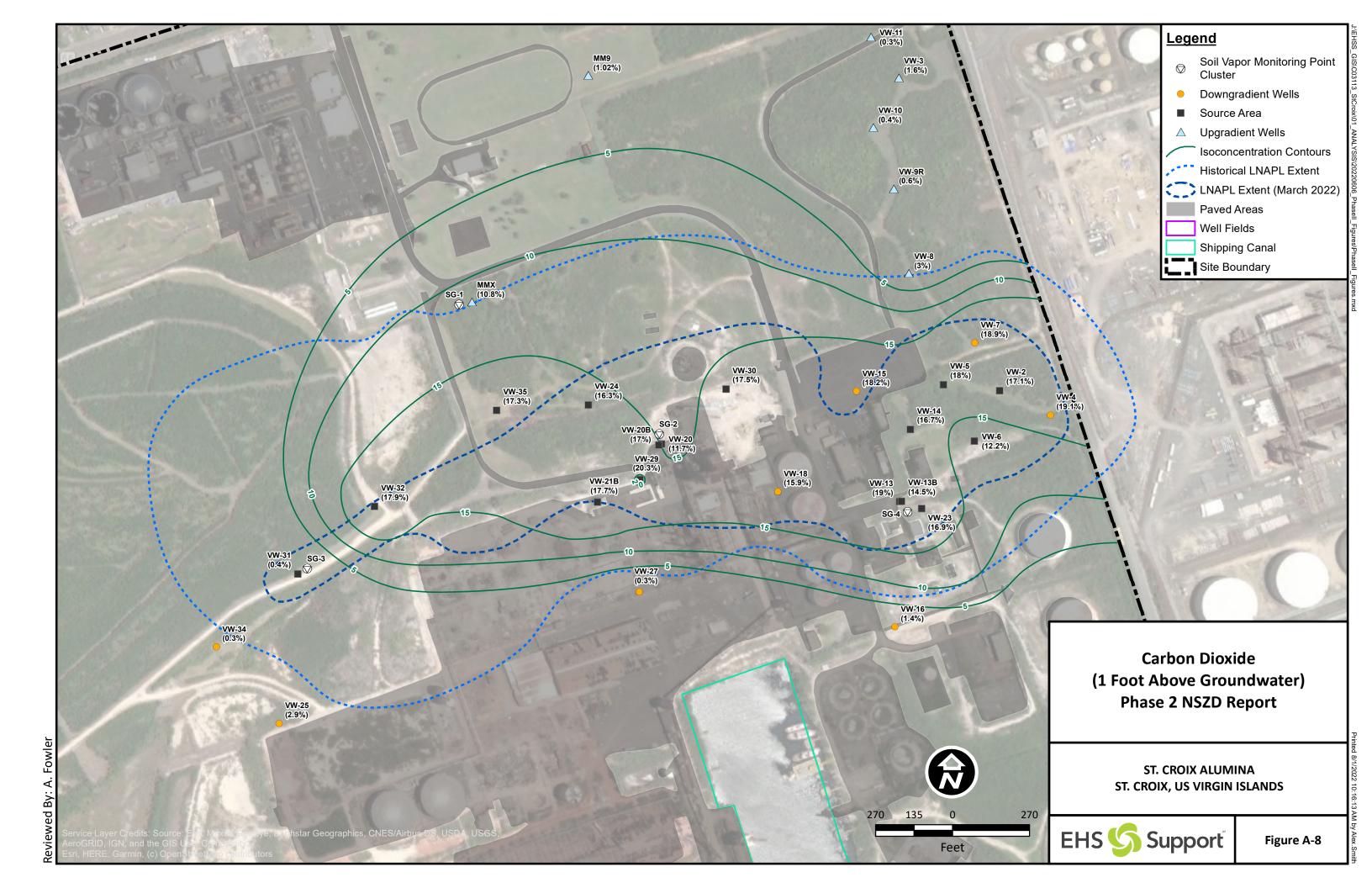


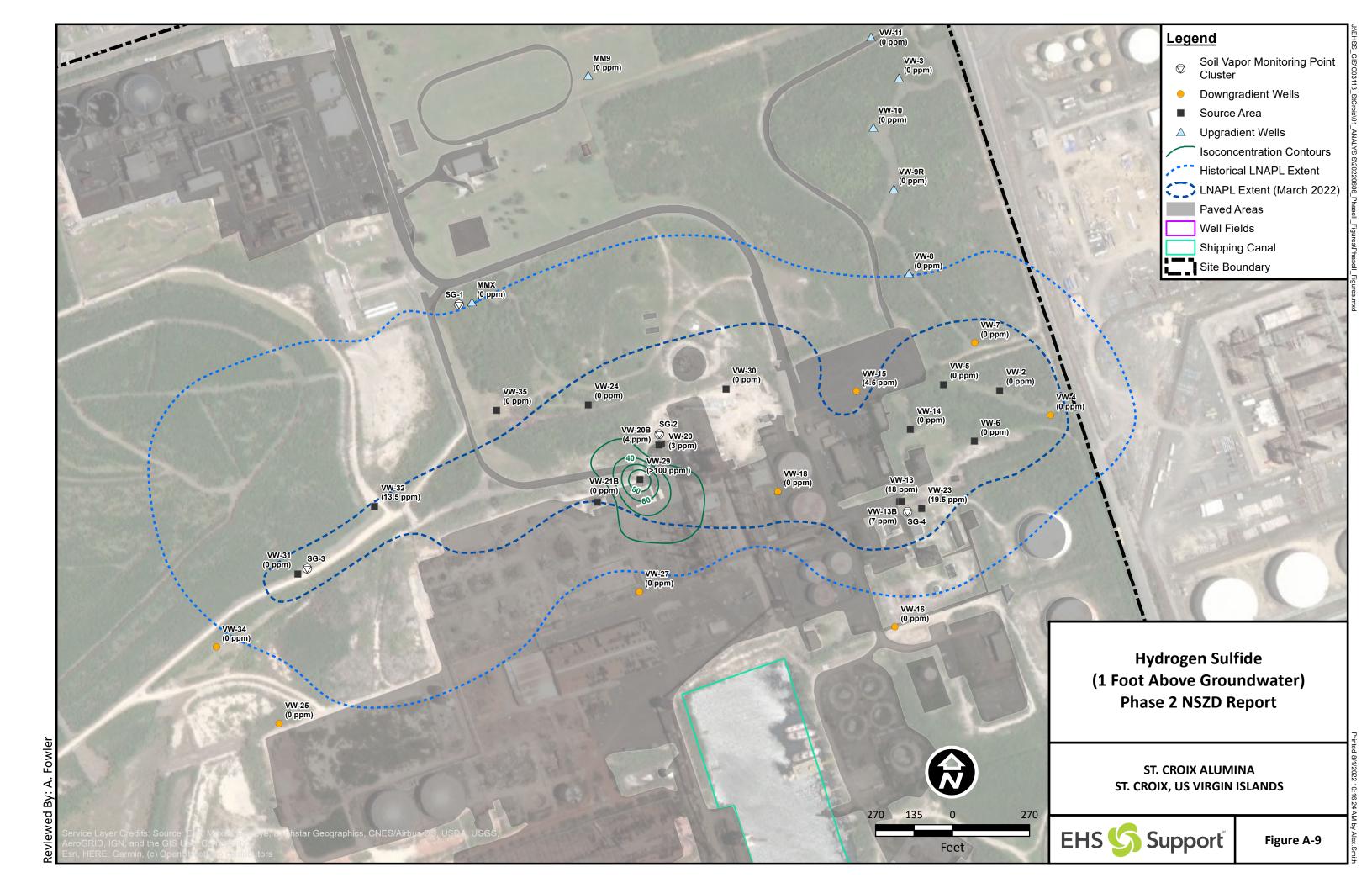


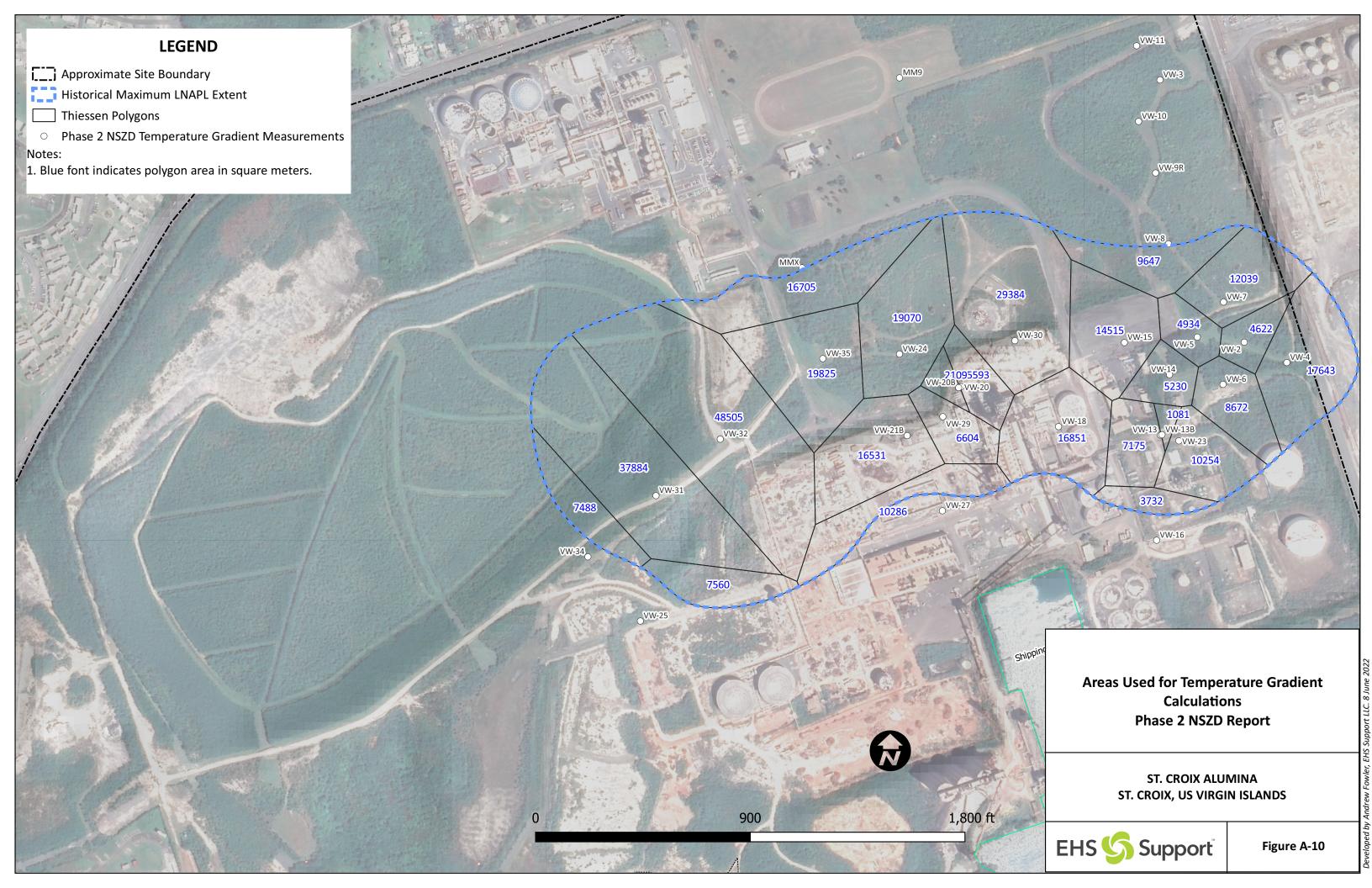


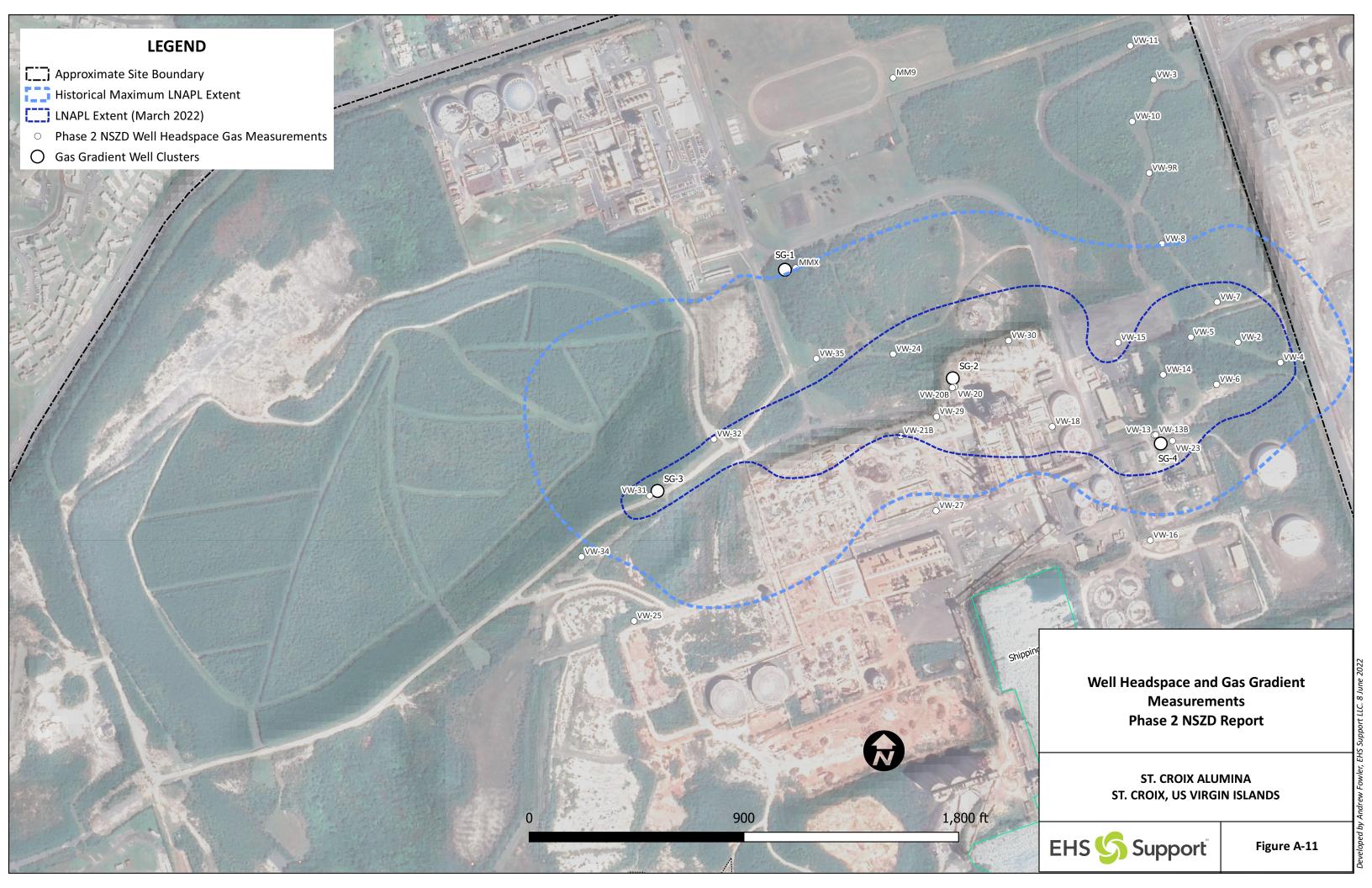


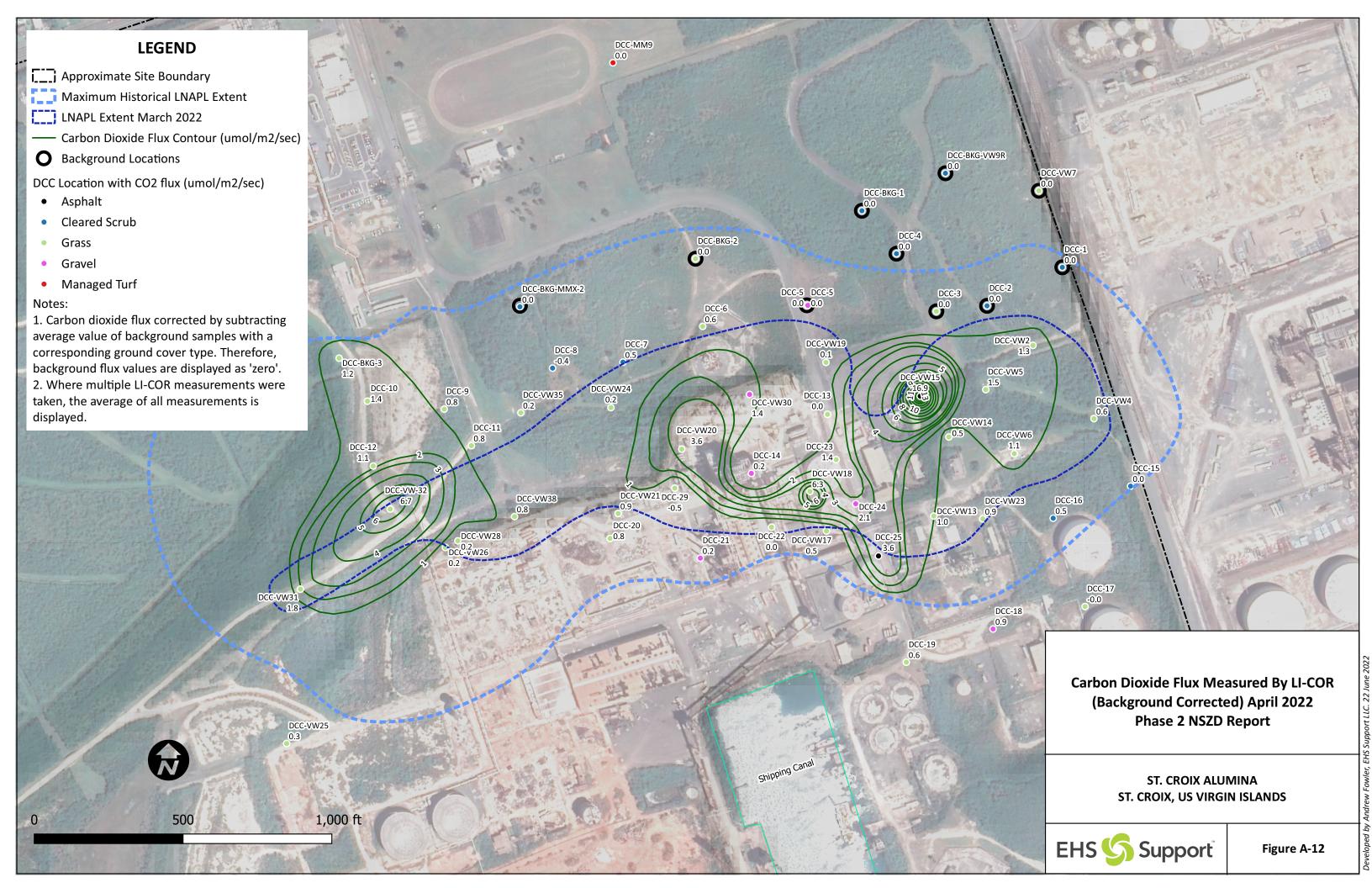


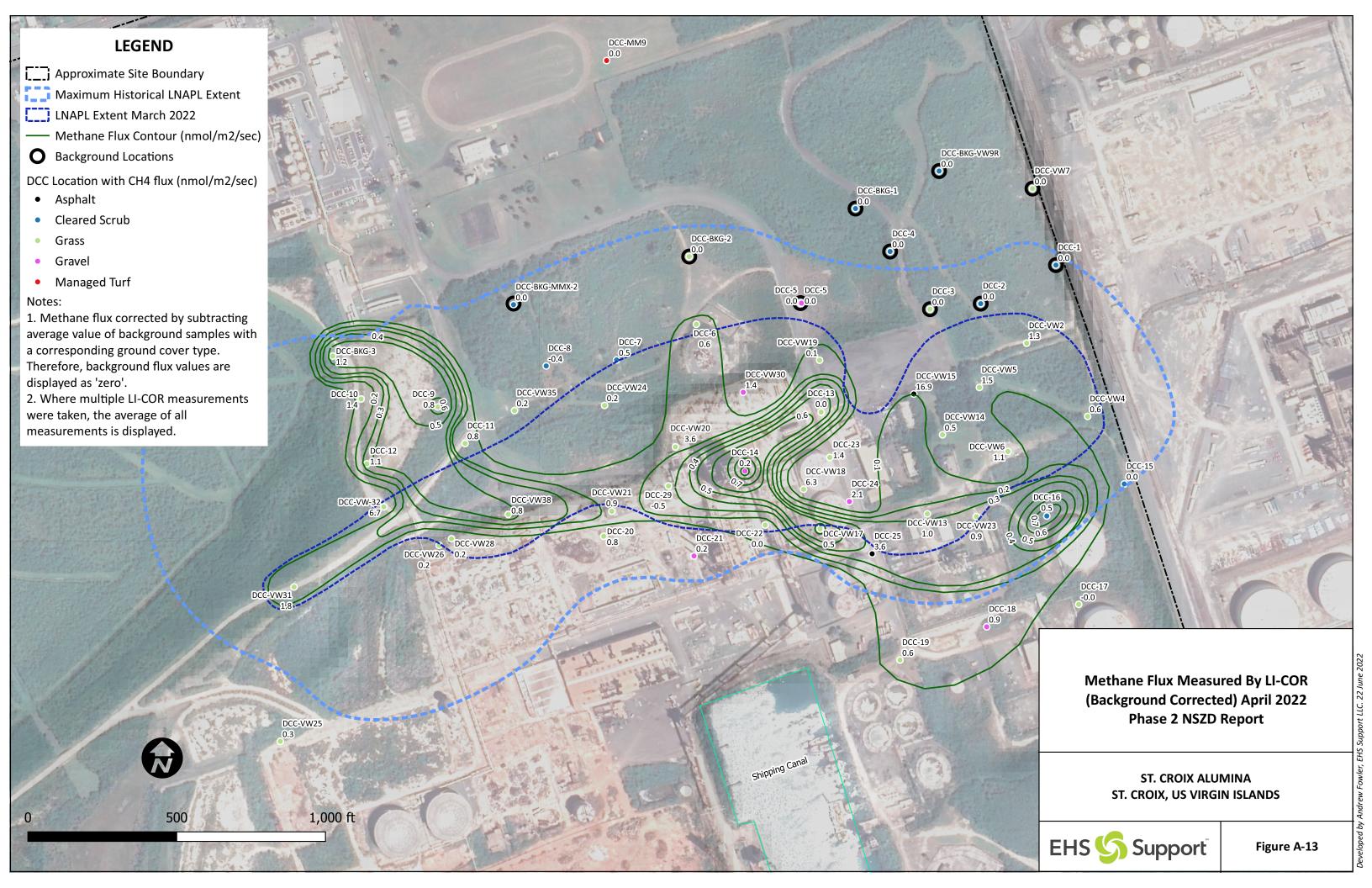


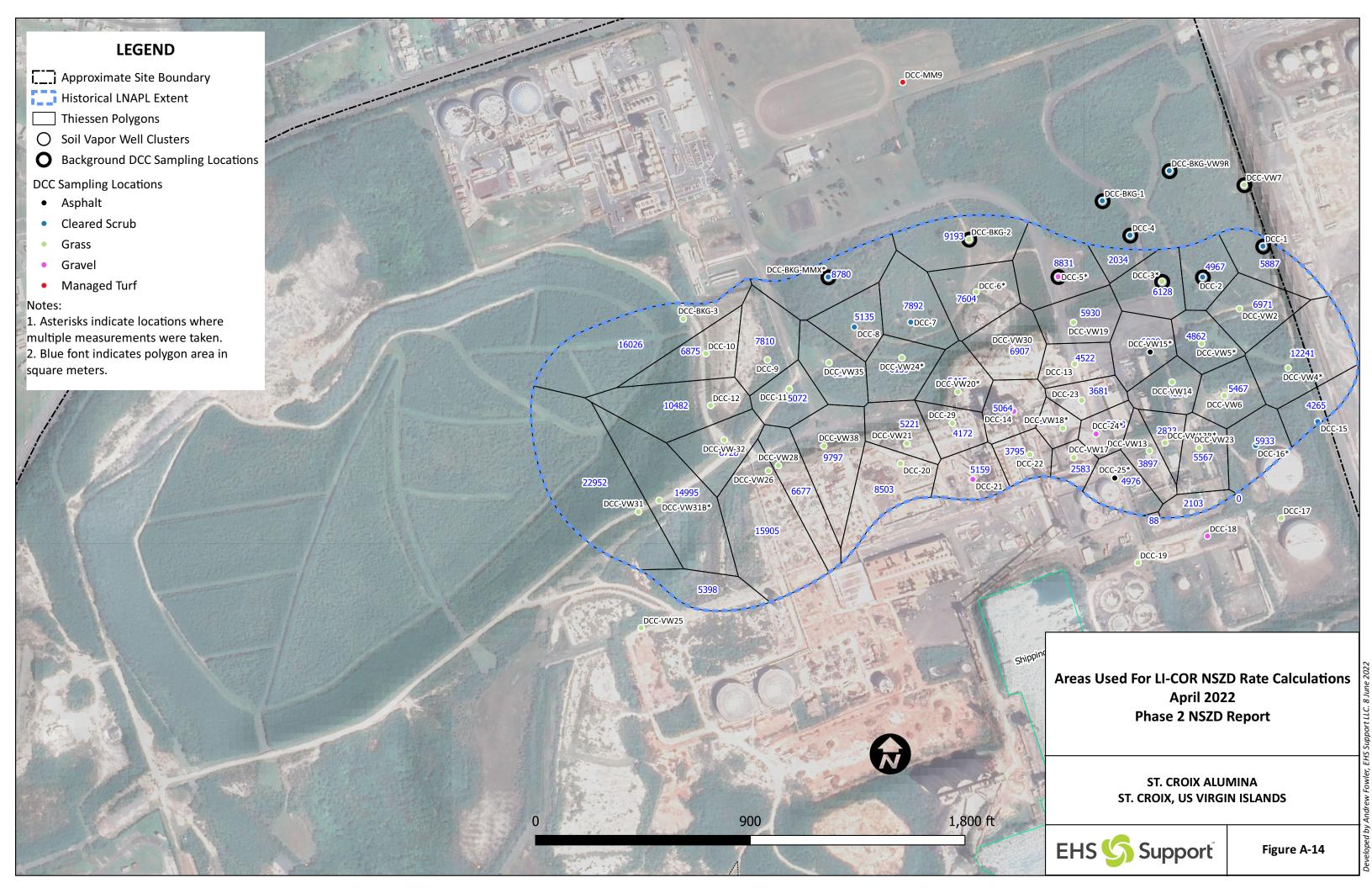


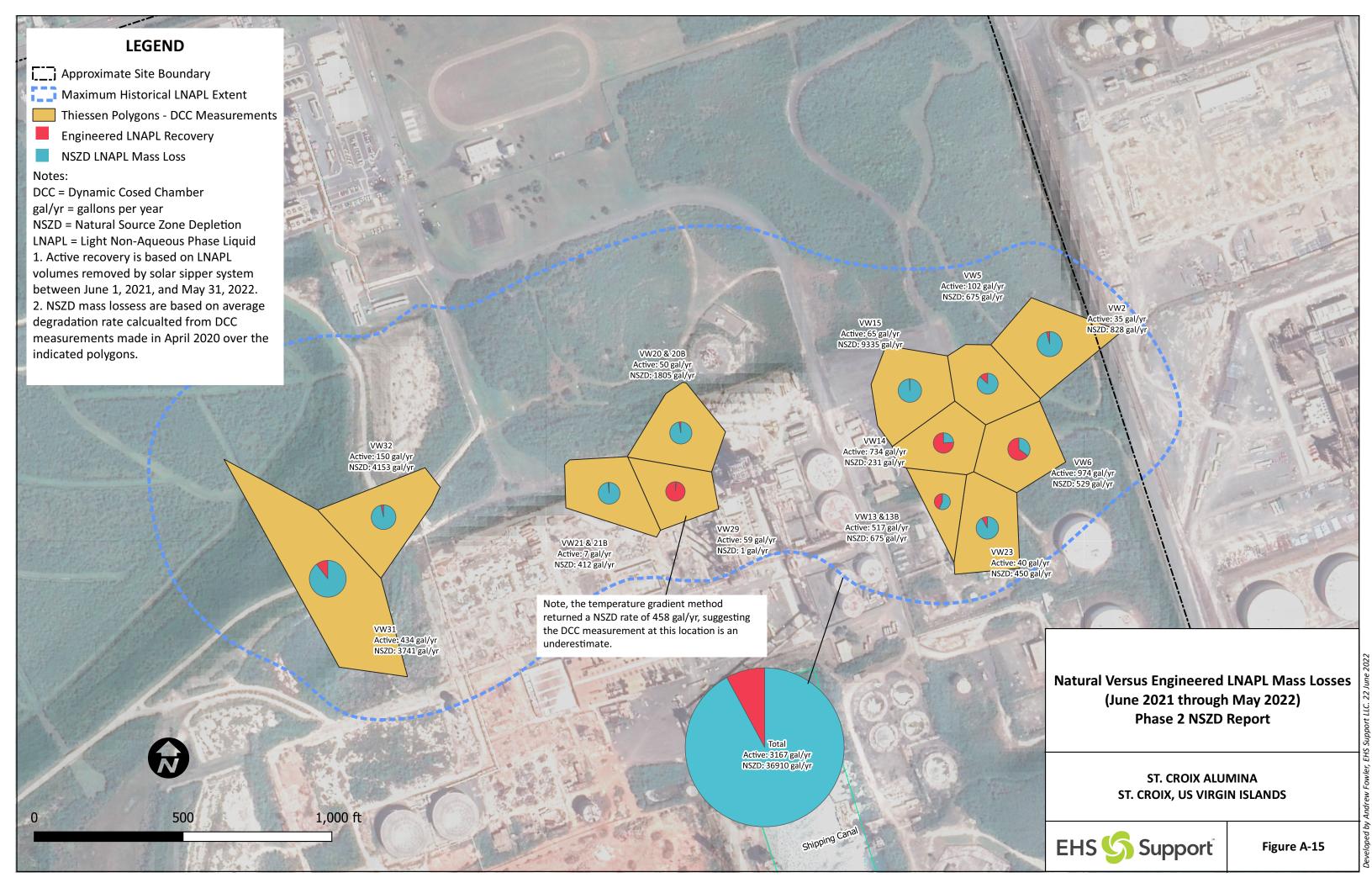














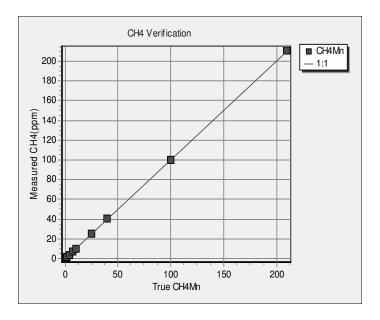
Attachment A Instrument Calibration Records

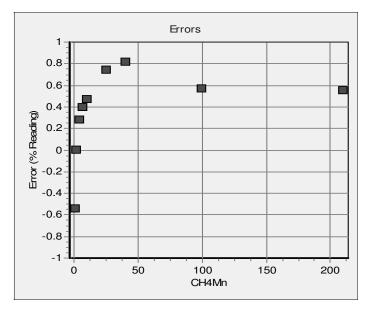
$\pmb{\text{LI-7810 CH}_4/\text{CO}_2/\text{H}_2\text{O} \text{ Analyzer}}$

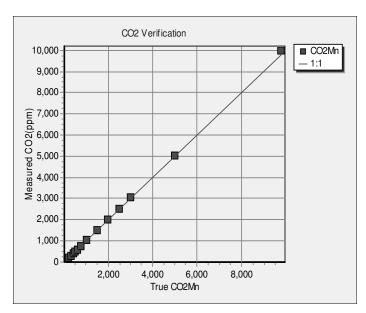
Calibration Certificate Serial Number <u>TG10-01340</u>

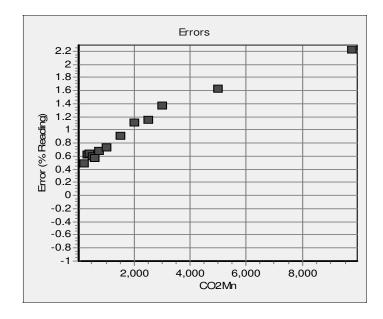
Date:	<u>18 Jan 2022</u>	Technician
	Code: 35081	Jerry F.

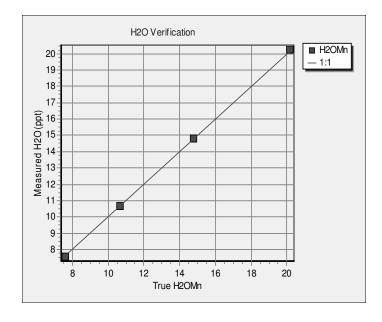
Verification Gas Assigned Values	Unit Under Test Measurements
2051 ppb CH4	2051 ppb CH4
9977 ppb CH4	<u>10023</u> ppb CH4
407.3 ppm CO2	409.9 ppm CO2
<u>1016.0</u> ppm CO2	<u>1023.5</u> ppm CO2

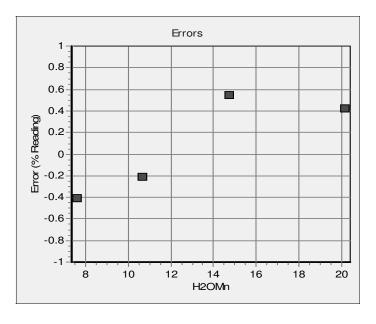










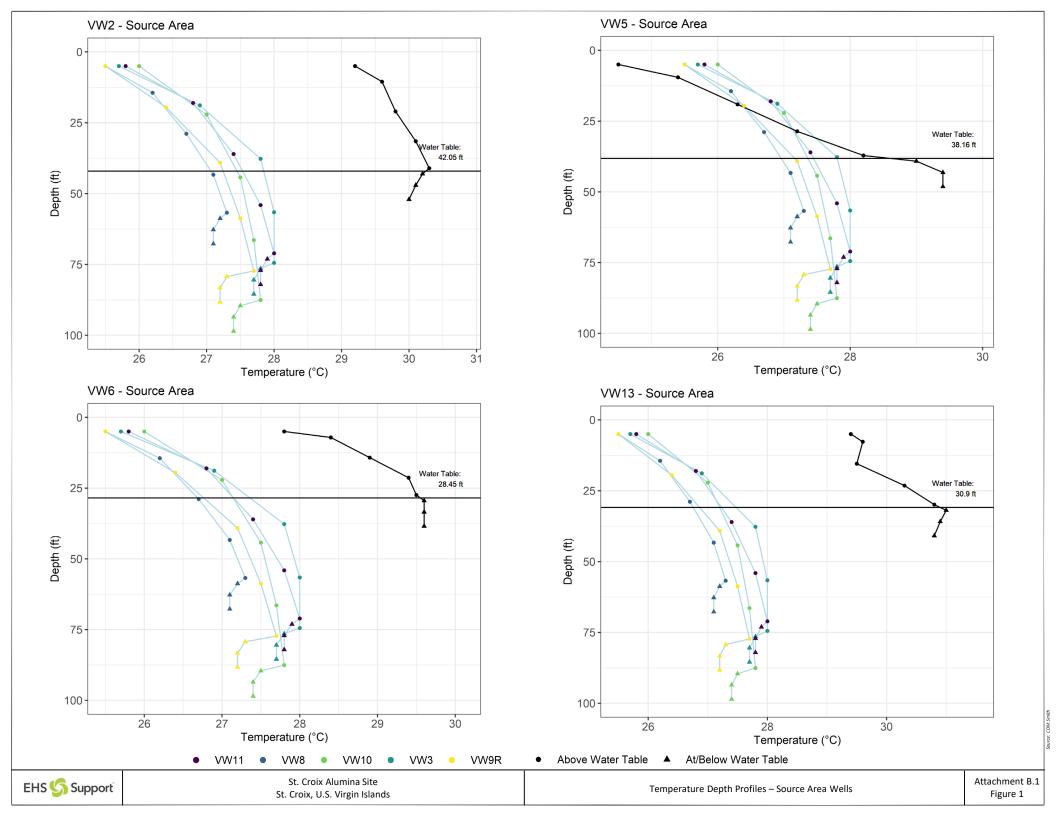


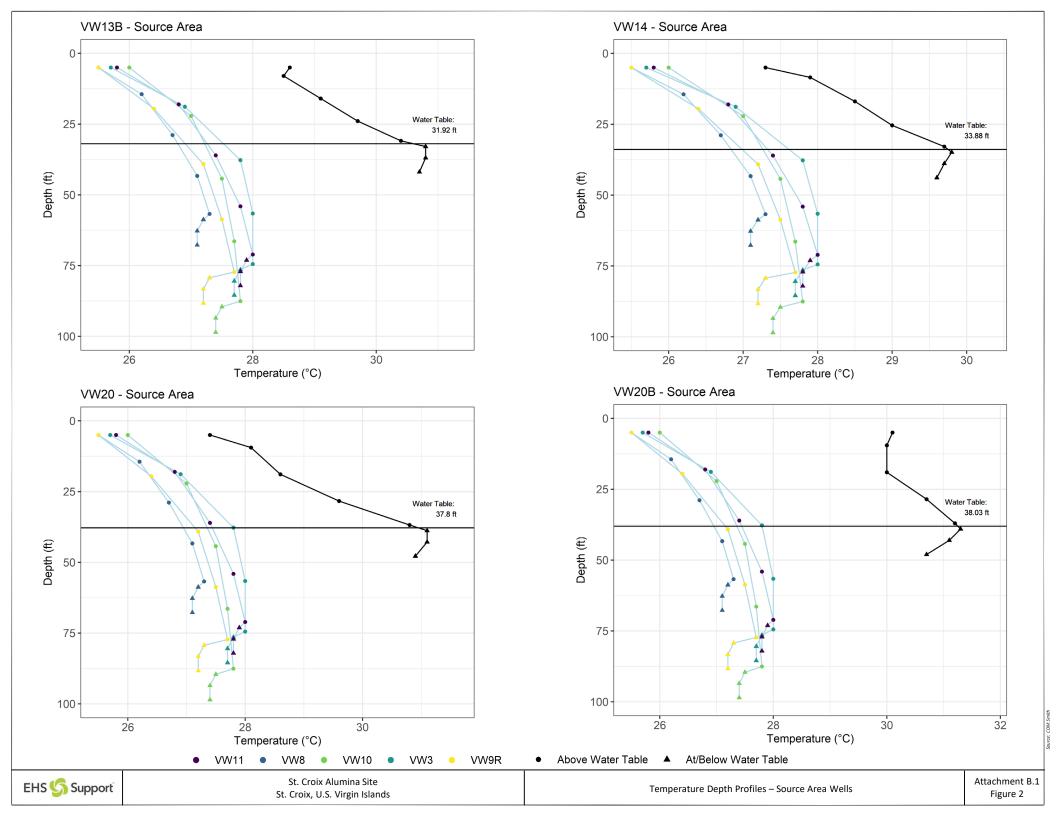


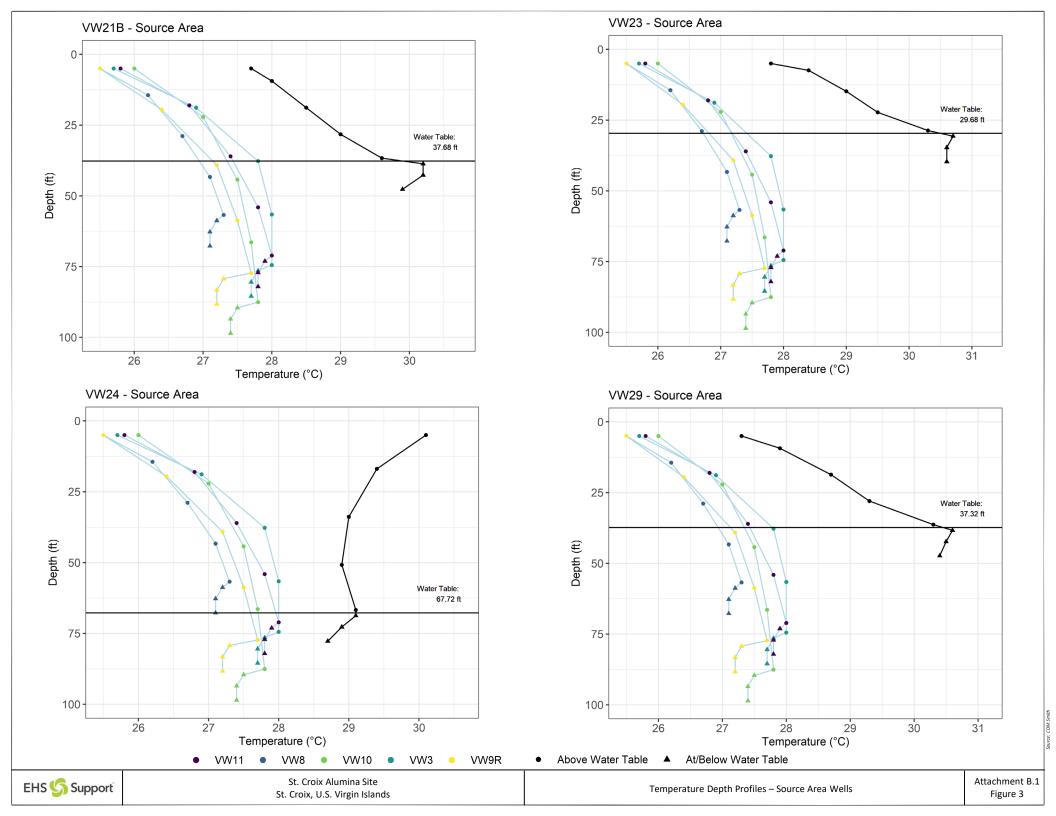
Attachment B Temperature Profiles

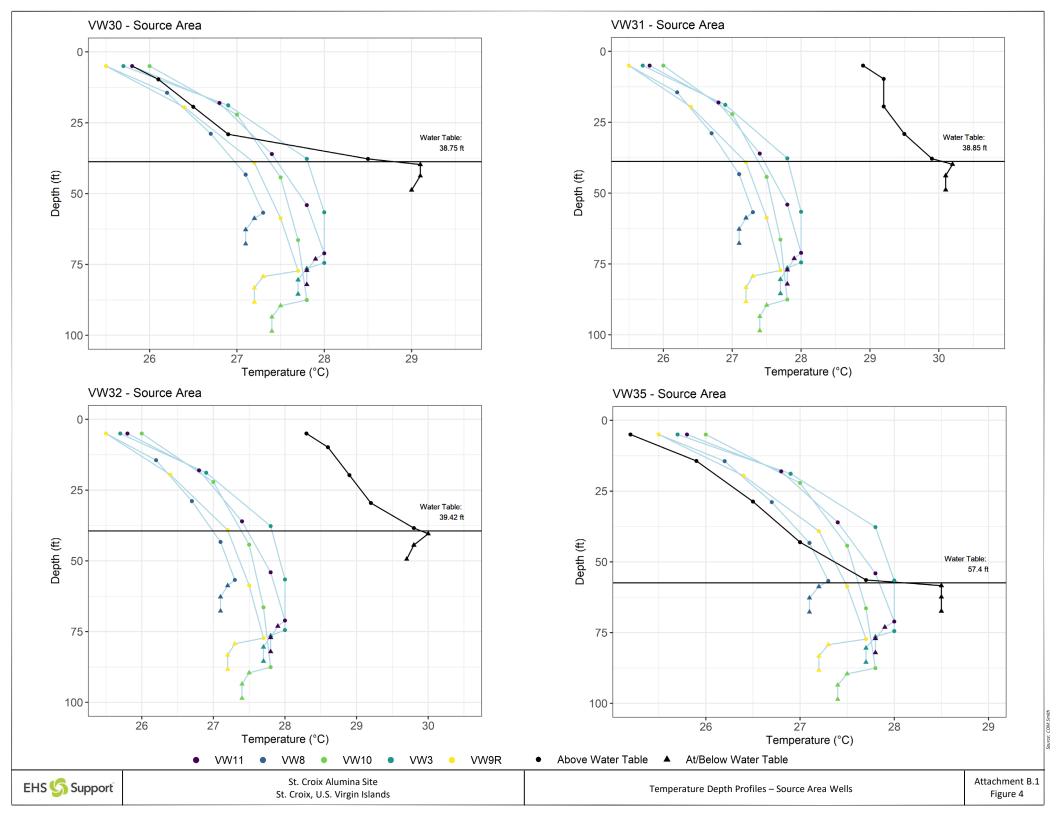


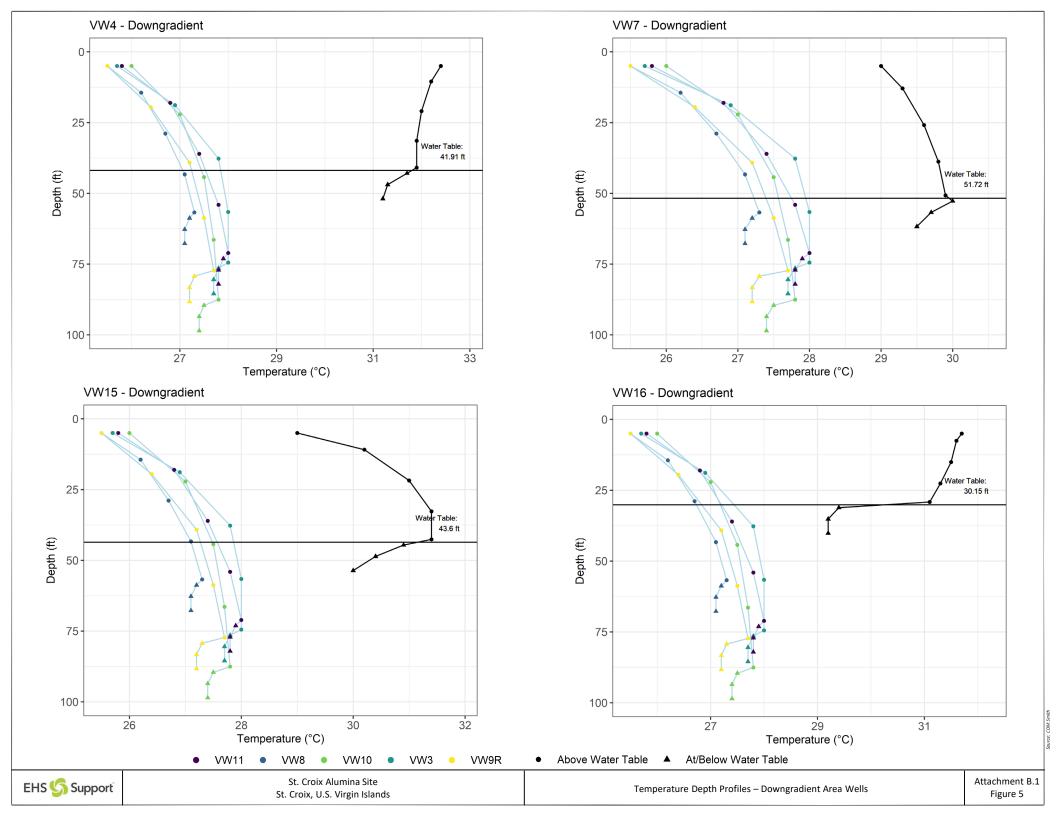
Attachment B.1 Measured Temperature Profiles

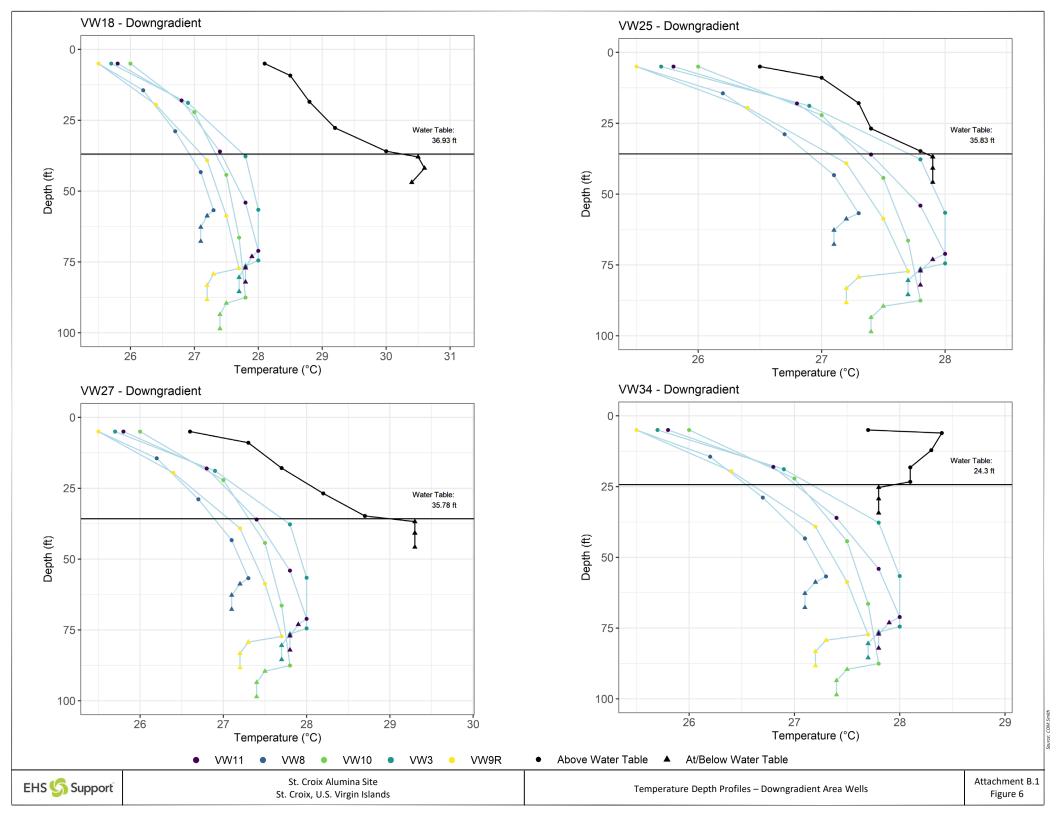




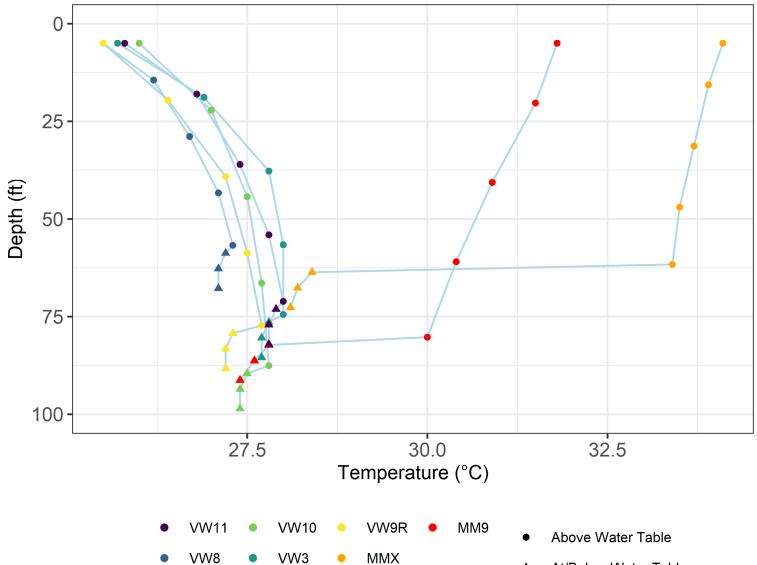








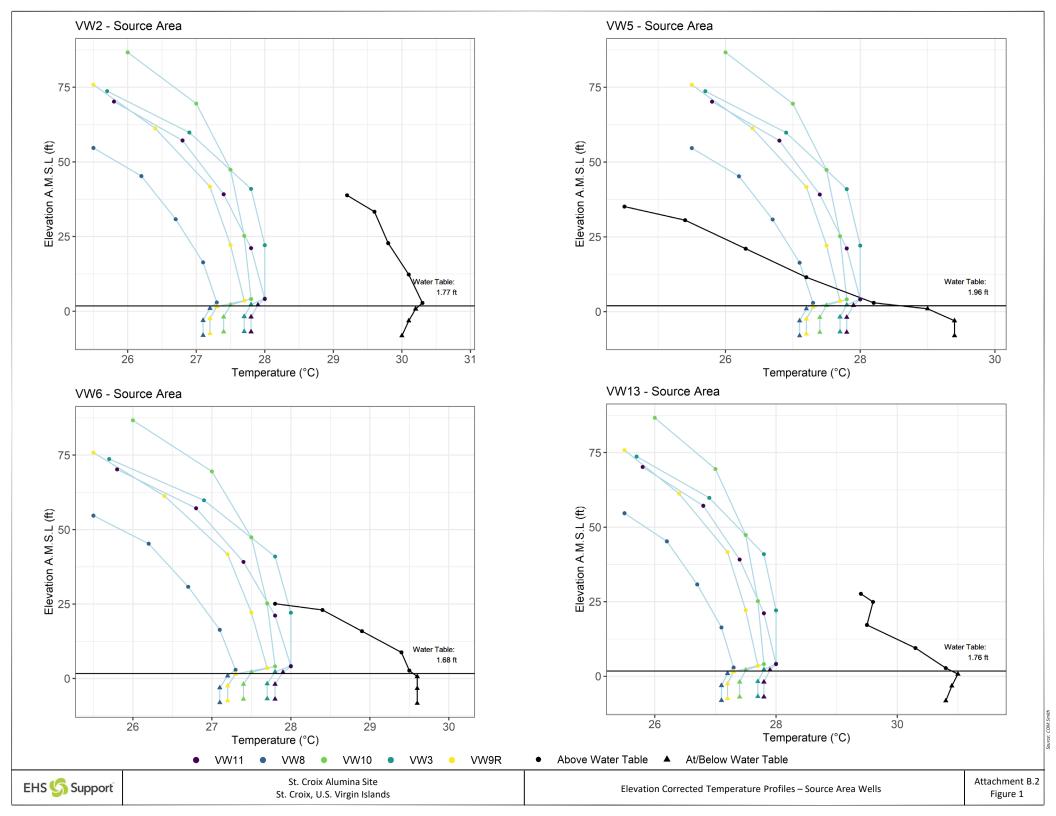
Background Wells

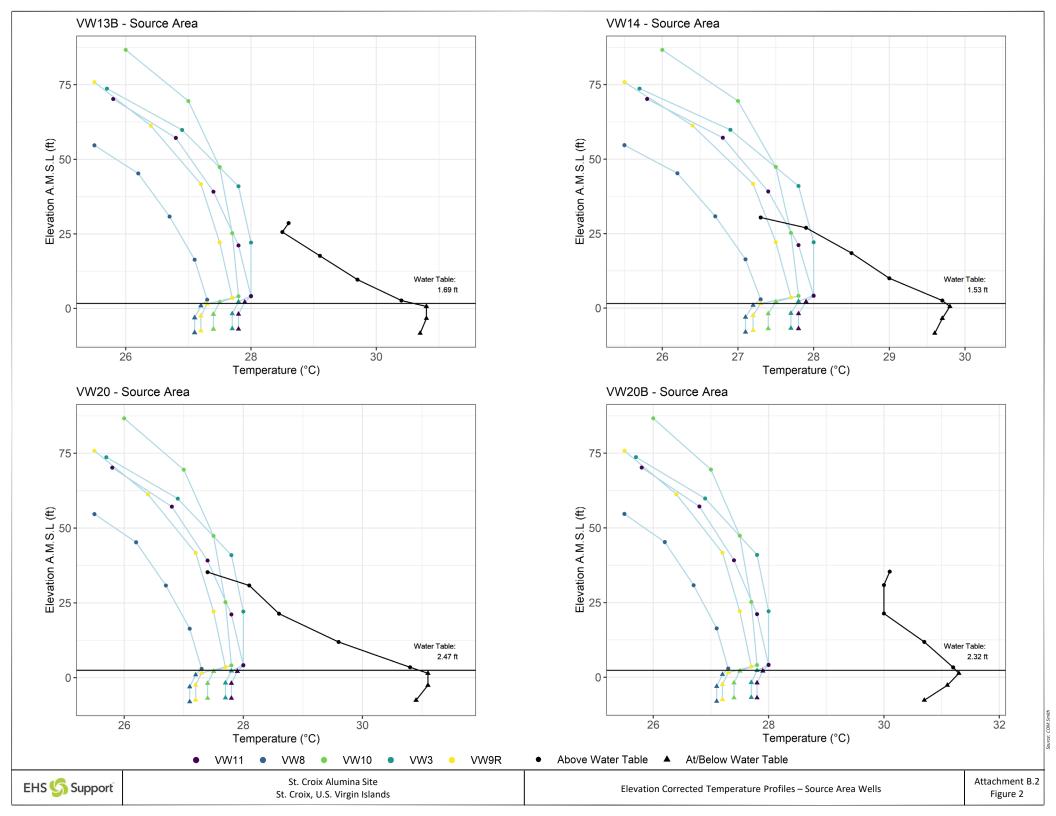


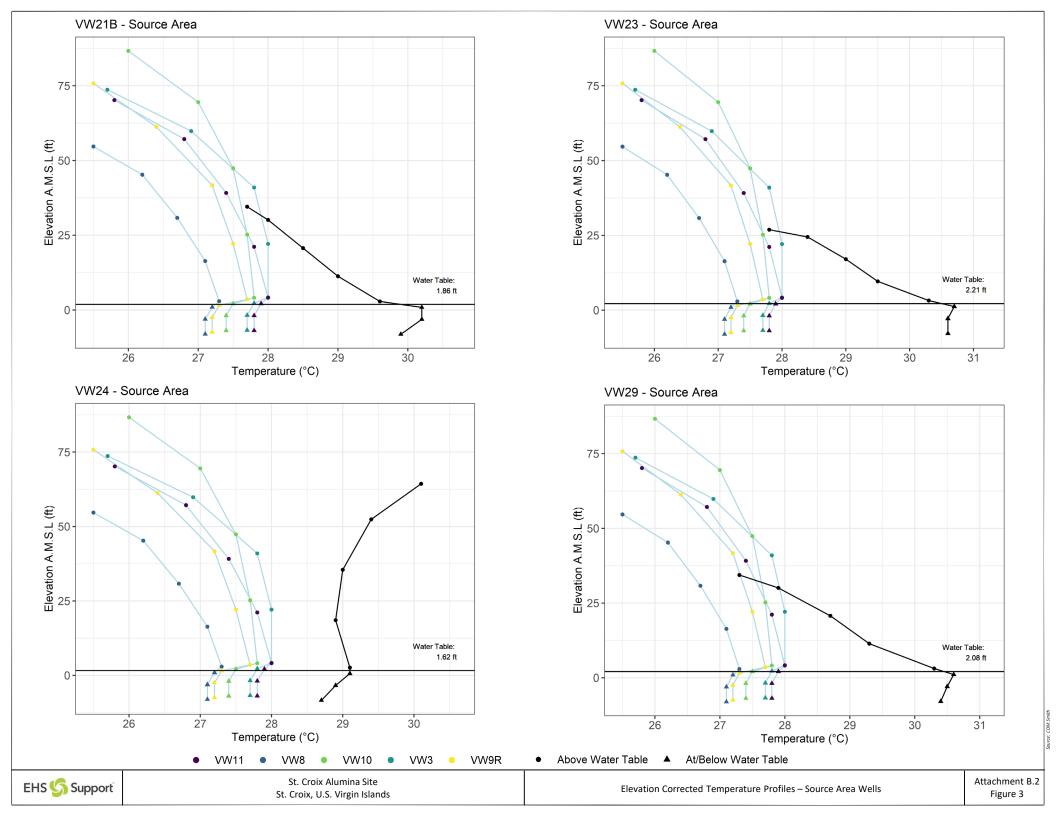
▲ At/Below Water Table

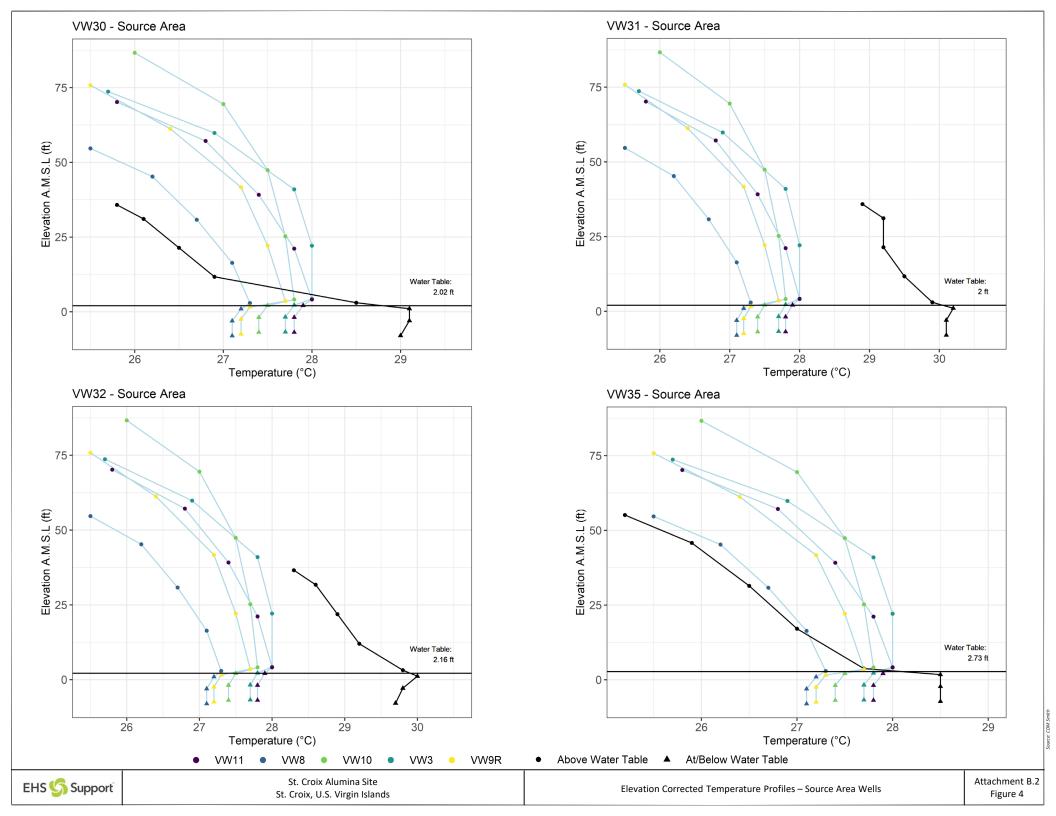


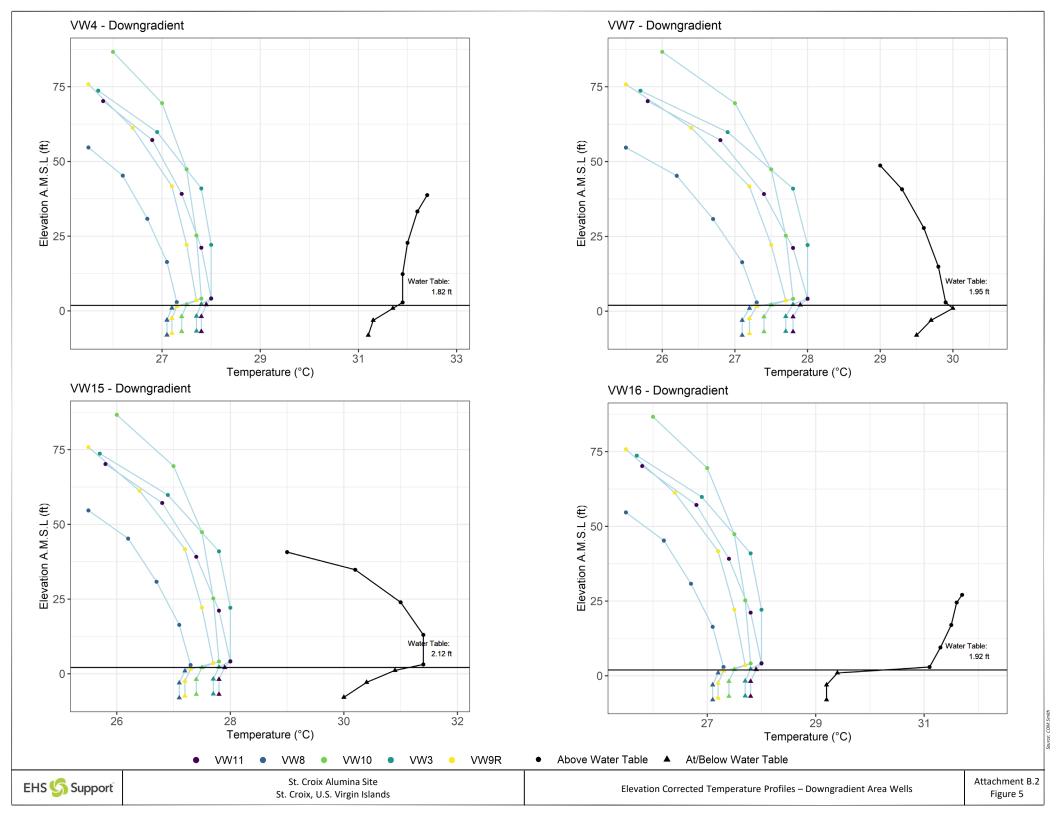
Attachment B.2 Temperature Profiles Corrected to Groundwater Elevation

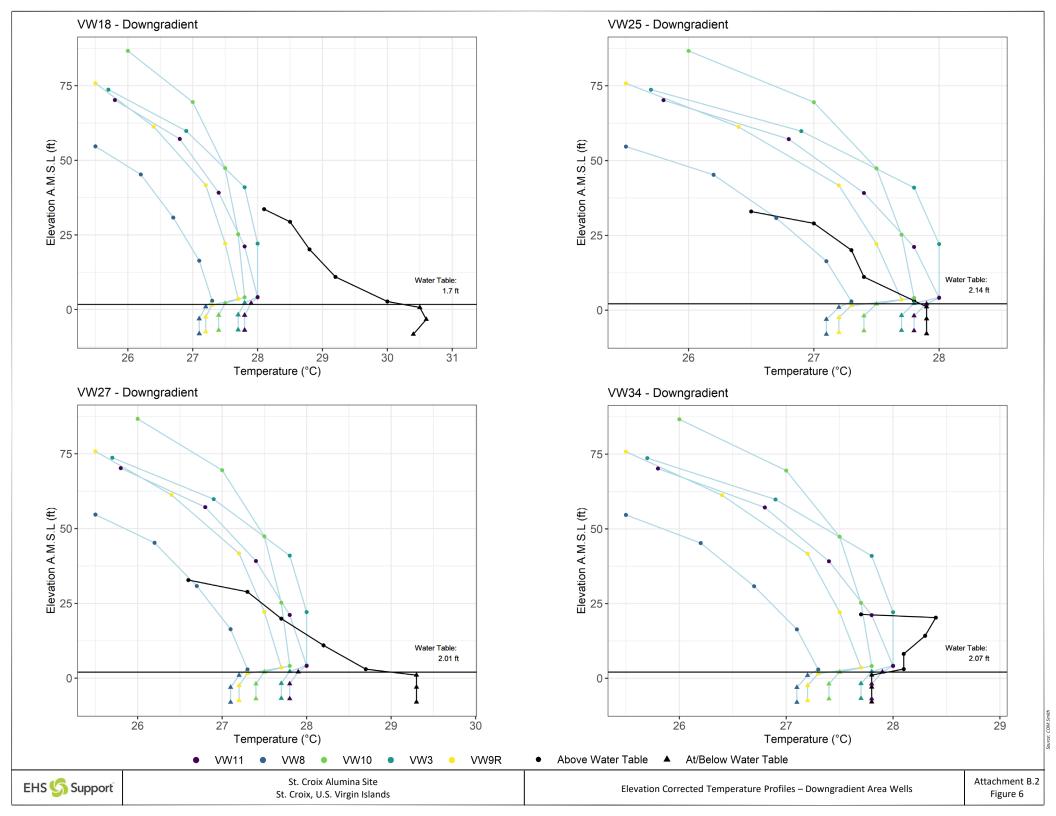




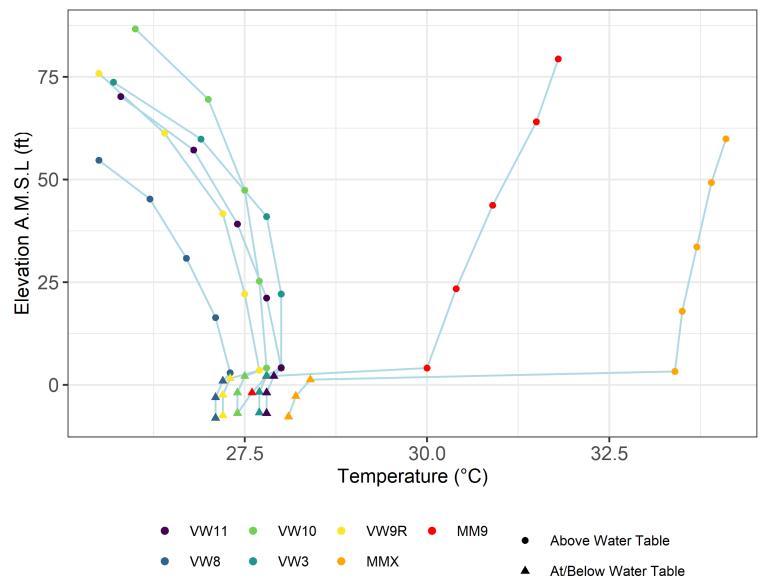






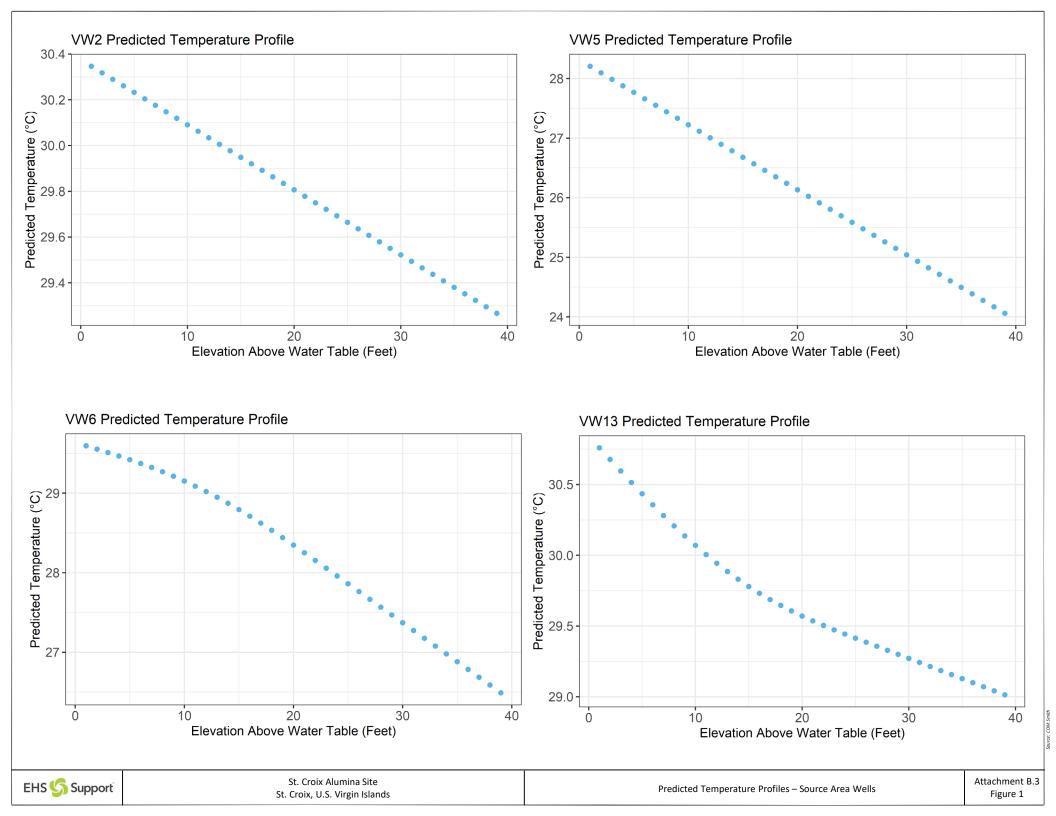


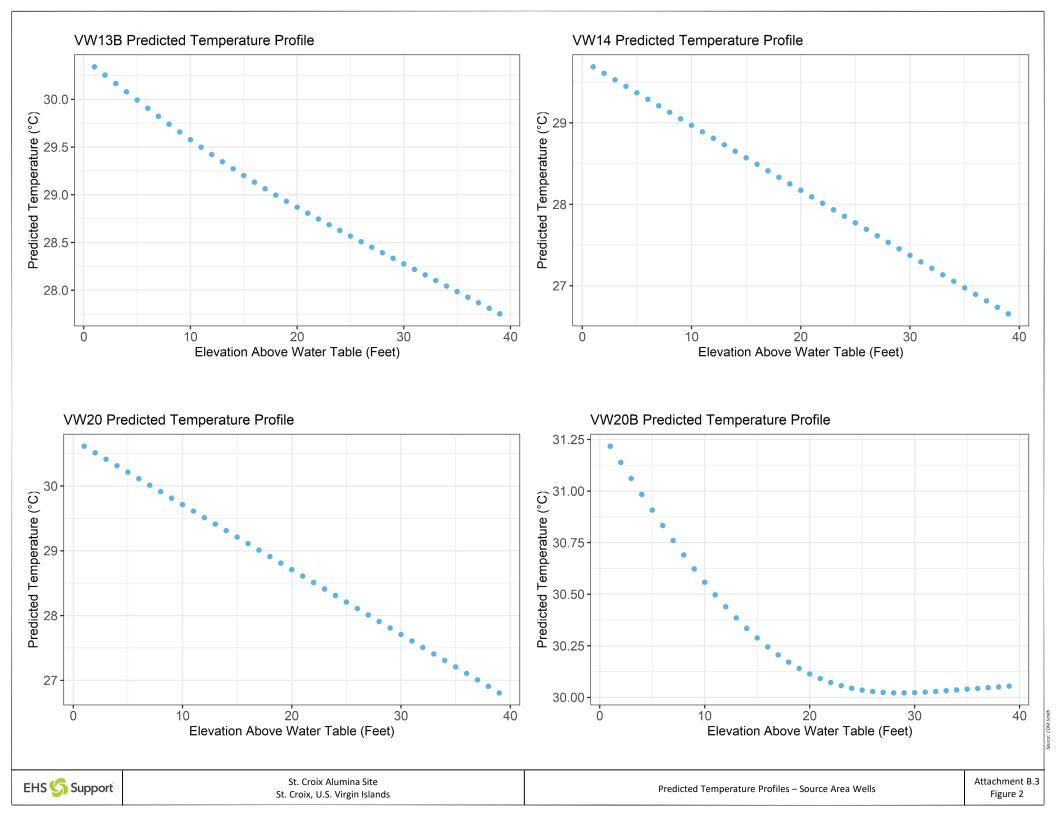
Background Wells

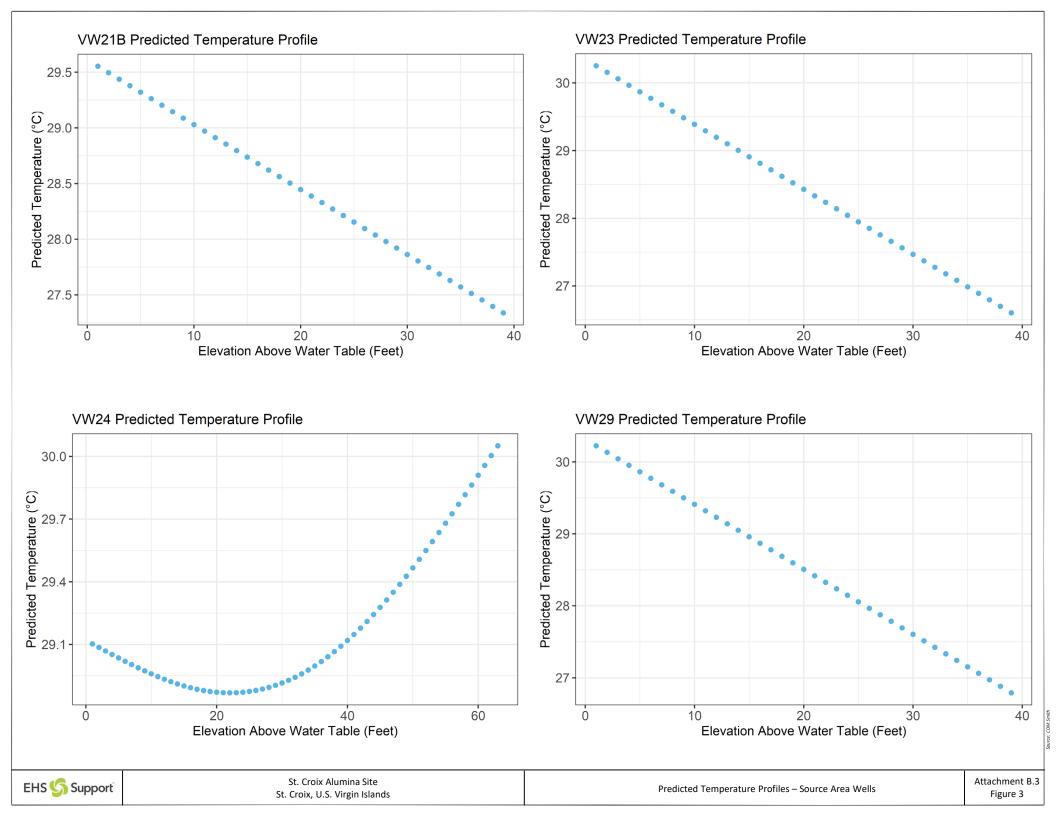


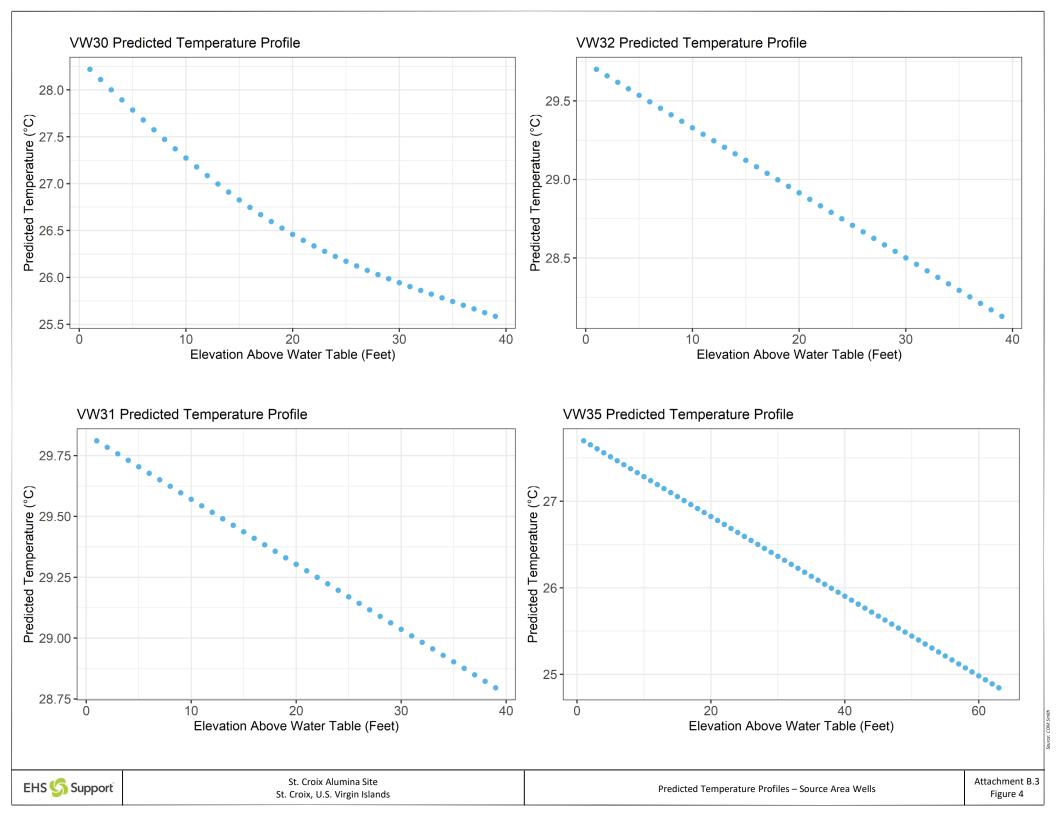


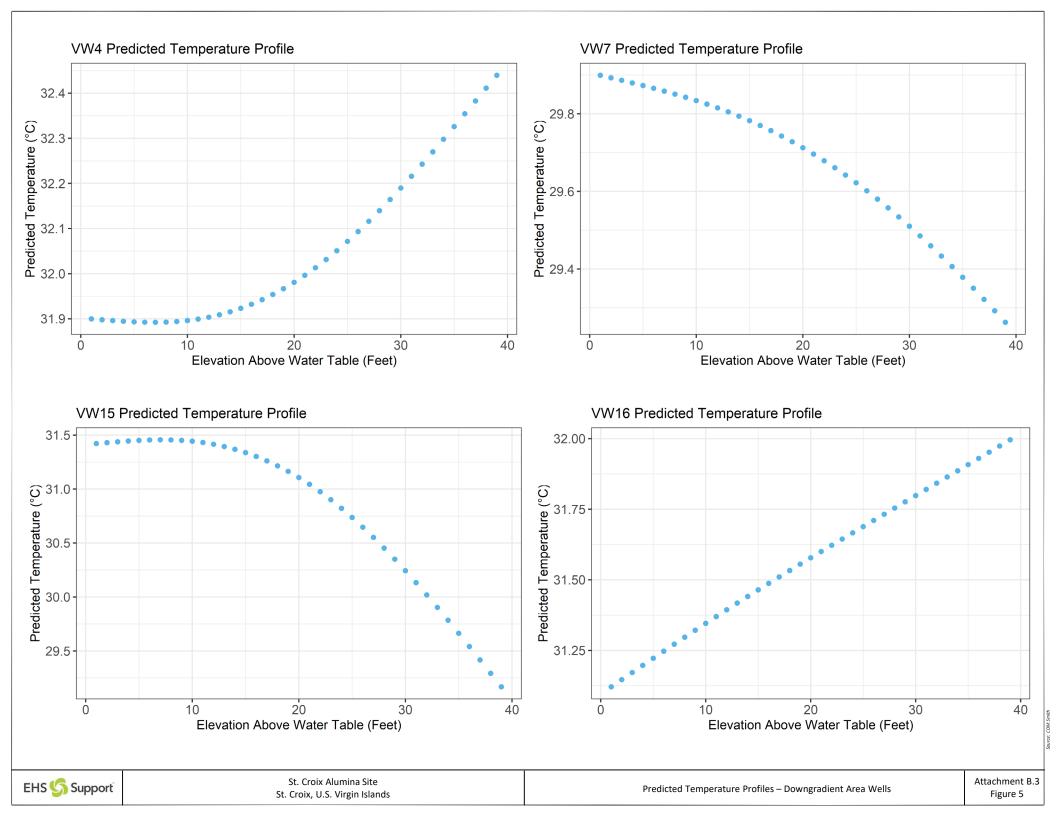
Attachment B.3 Predicted Temperature Profiles

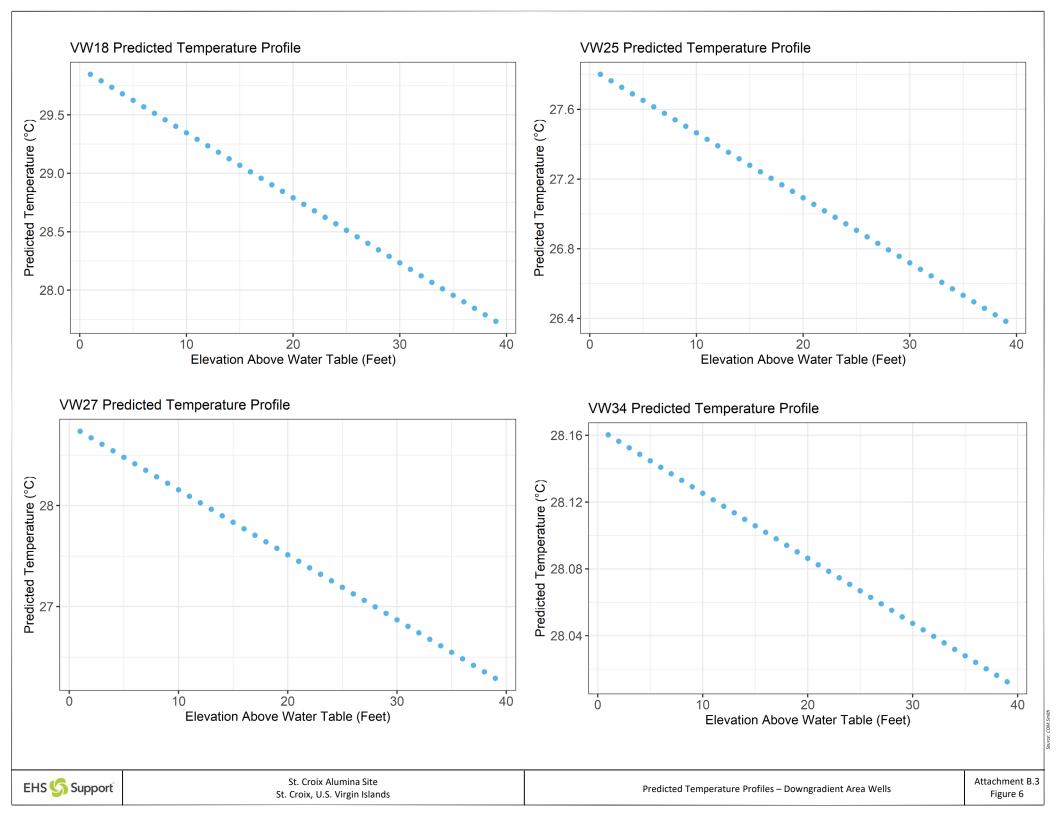






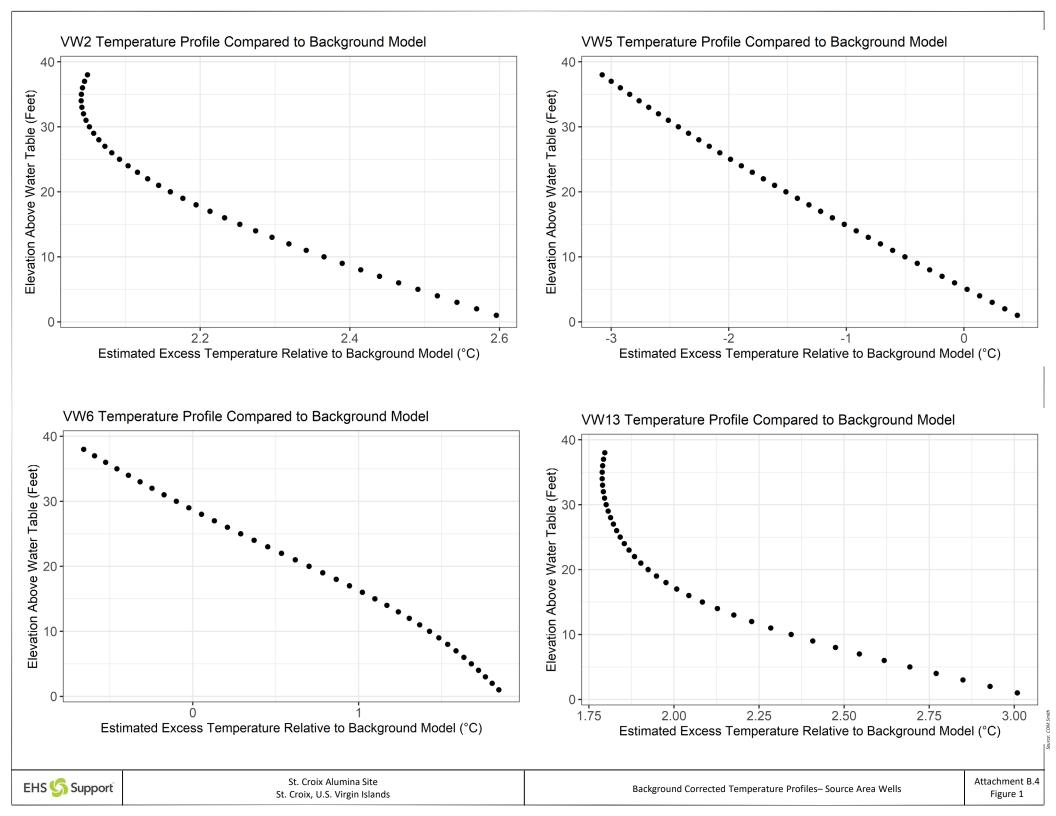


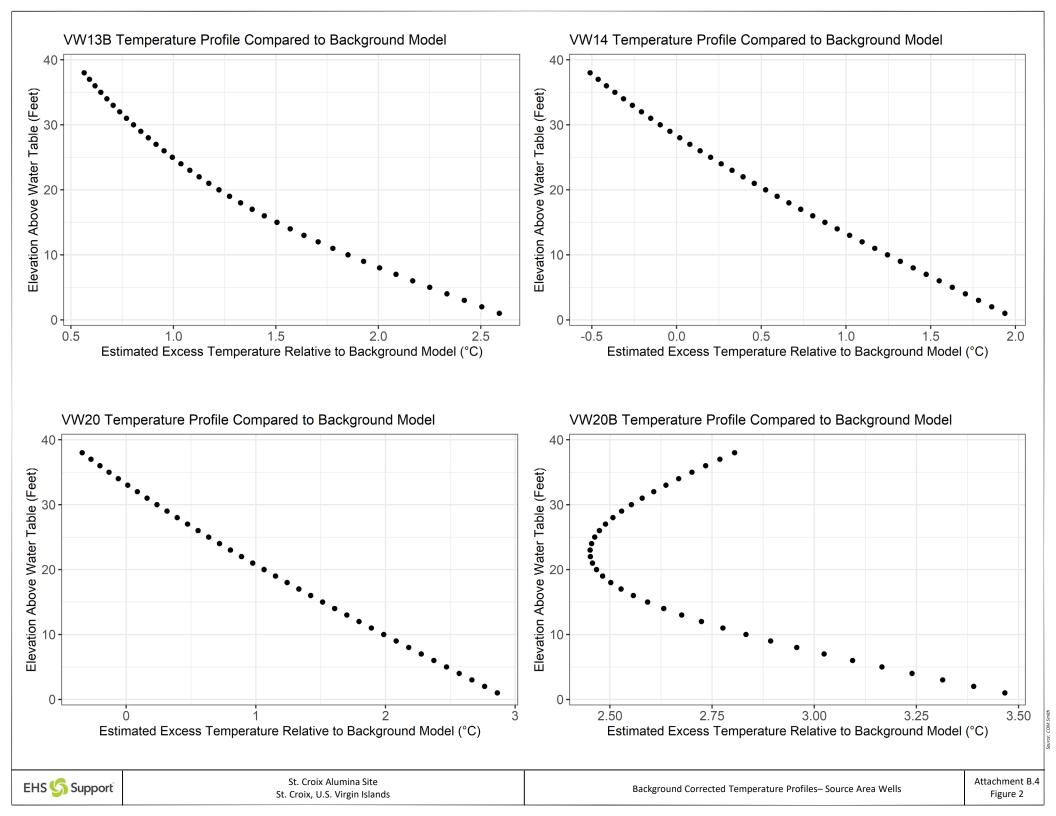


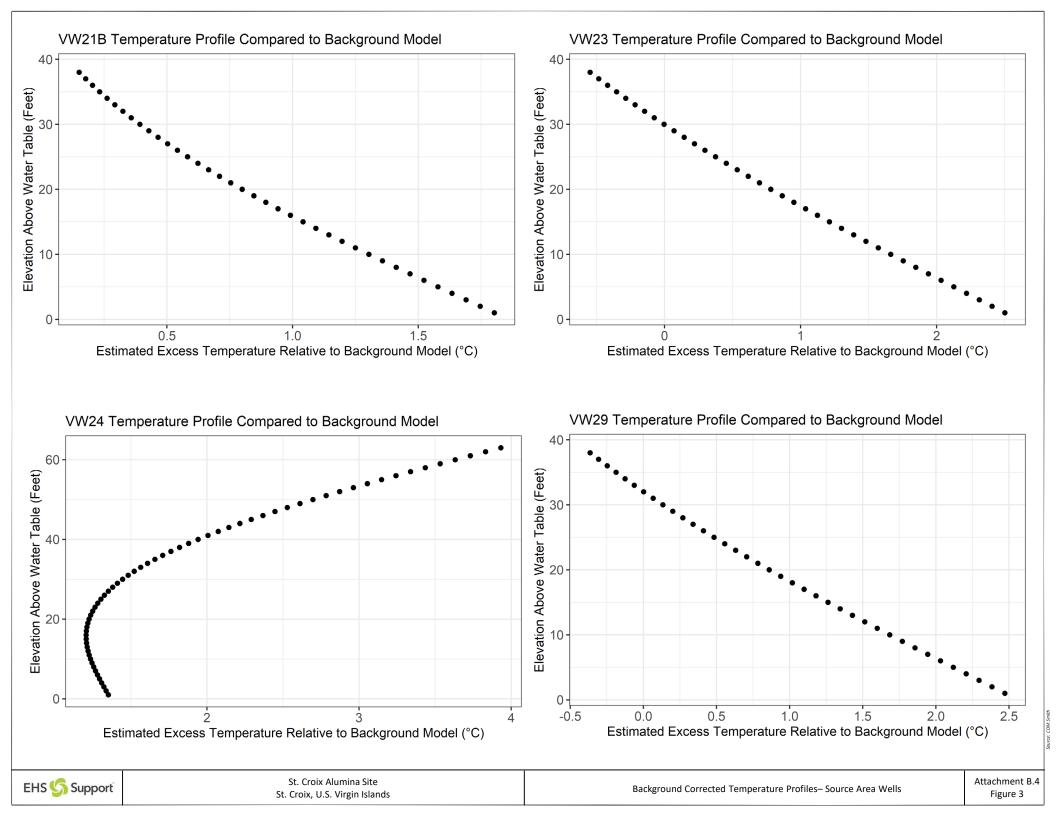


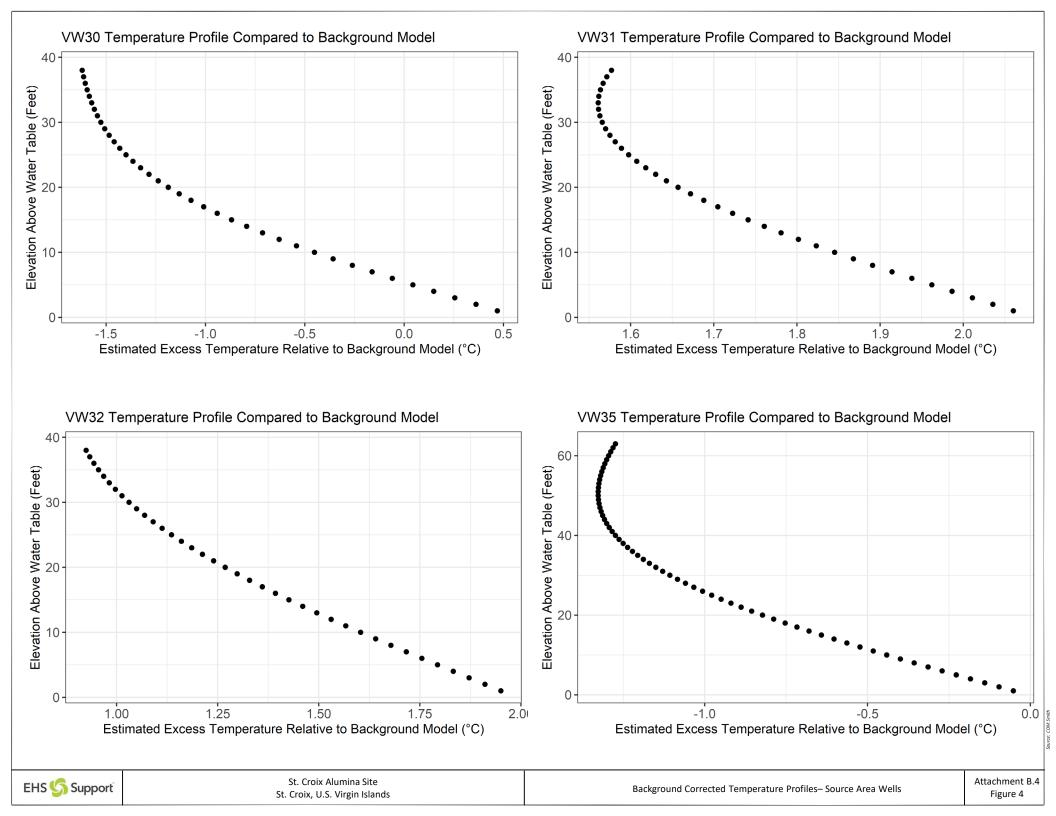


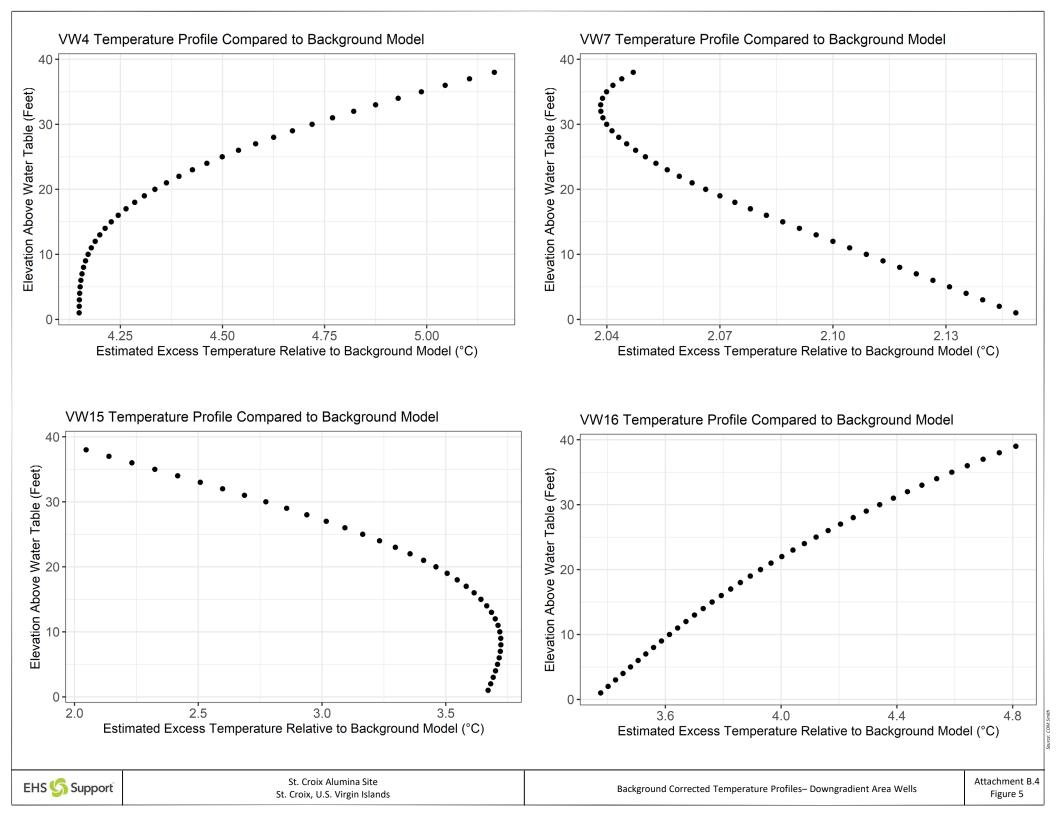
Attachment B.4 Background Corrected Temperature Profiles

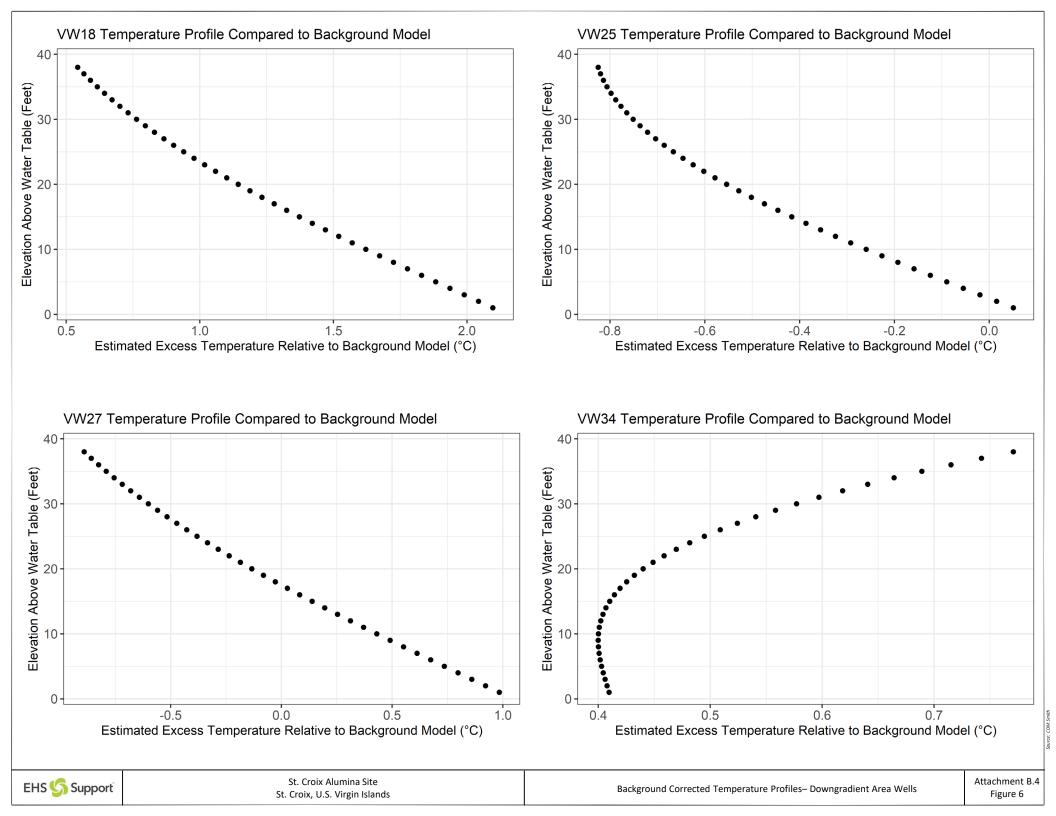










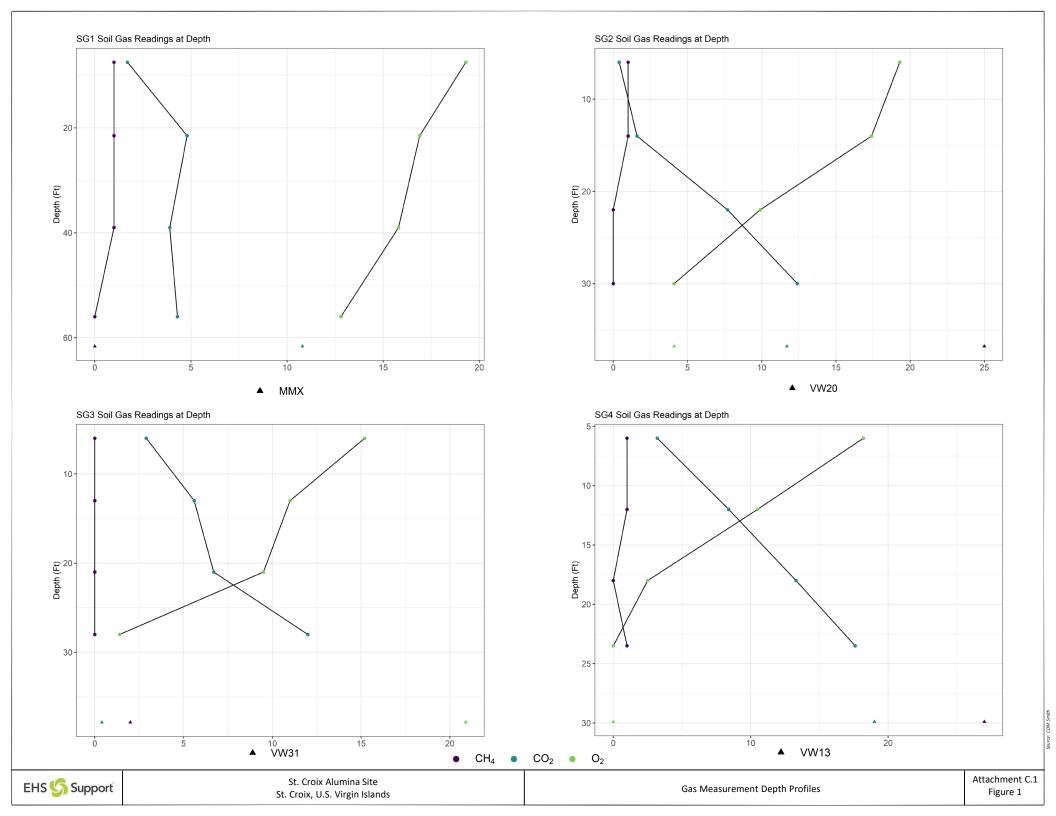


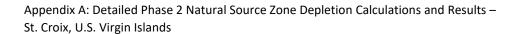


Attachment C Gas Concentration Profiles



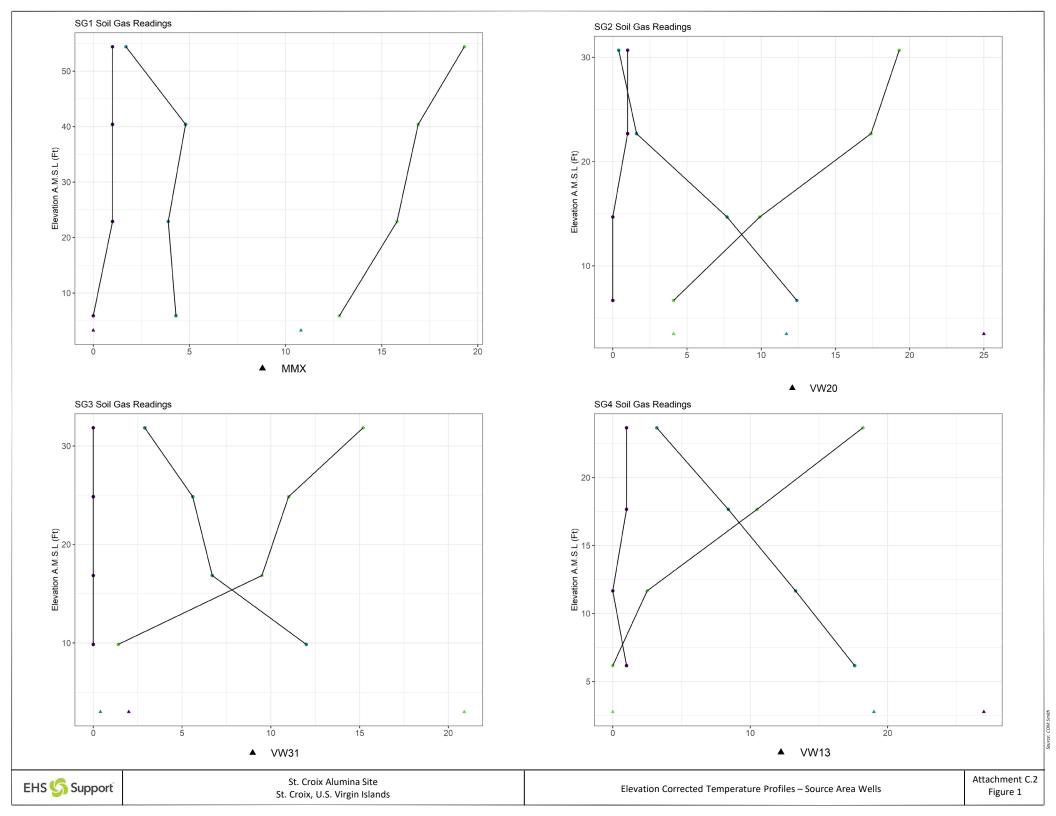
Attachment C.1 Measured Gas Concentration Profiles





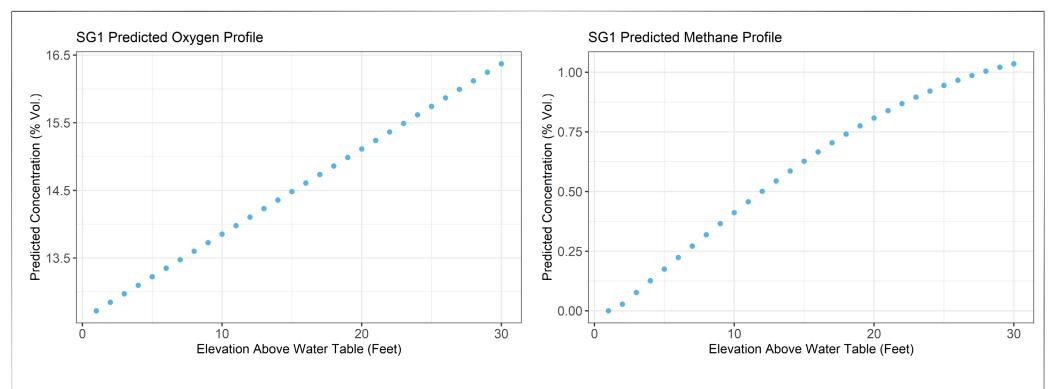


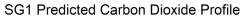
Attachment C.2 Gas Concentration Profiles Corrected to Groundwater Elevation

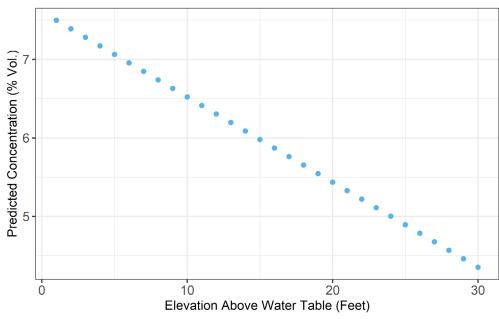


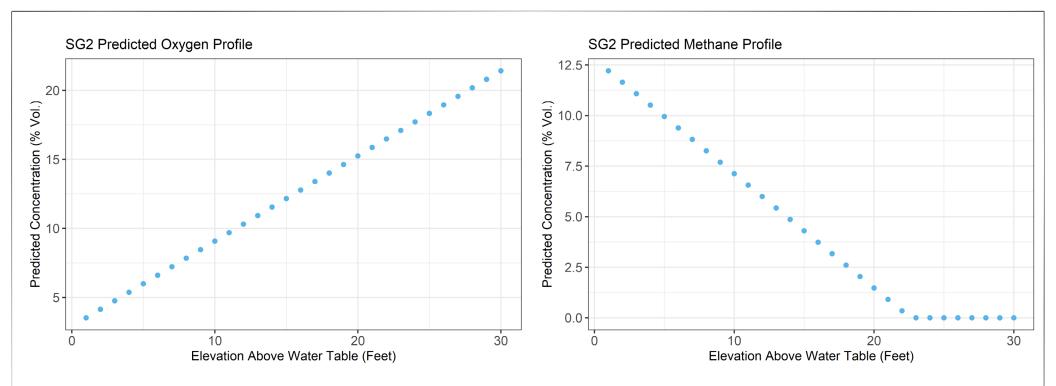


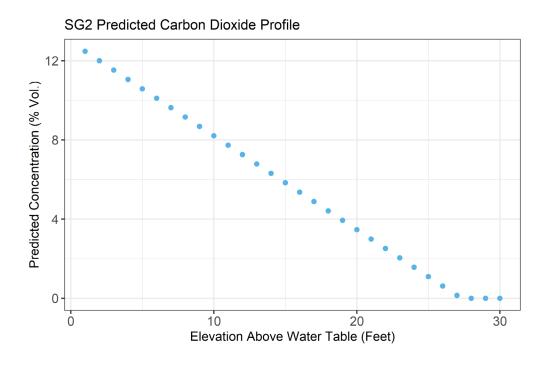
Attachment C.3 Predicted Gas Concentration Profiles

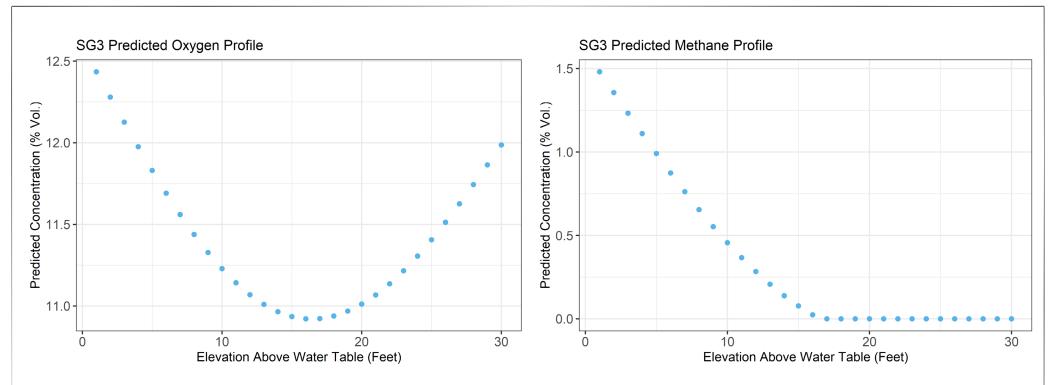


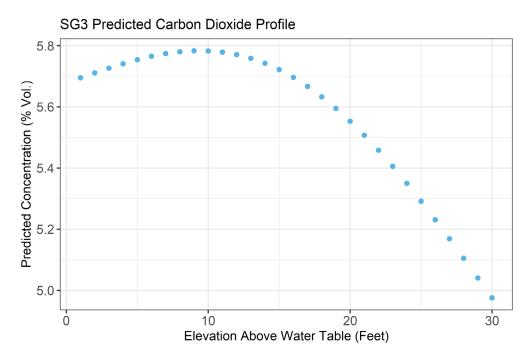


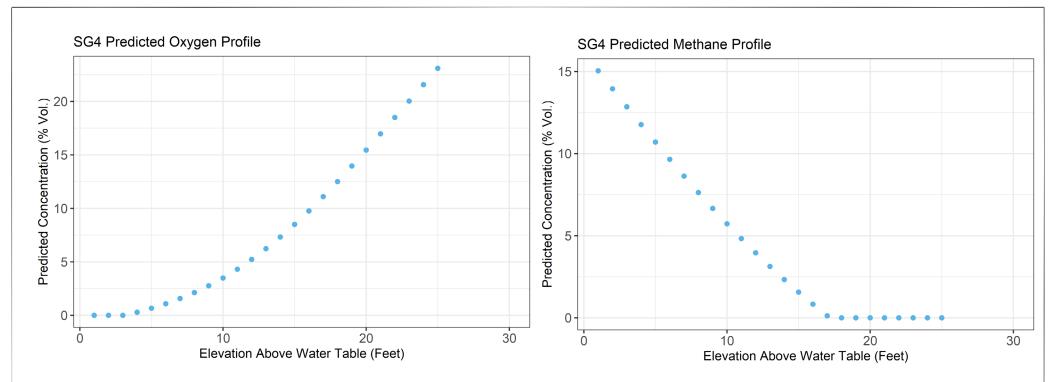


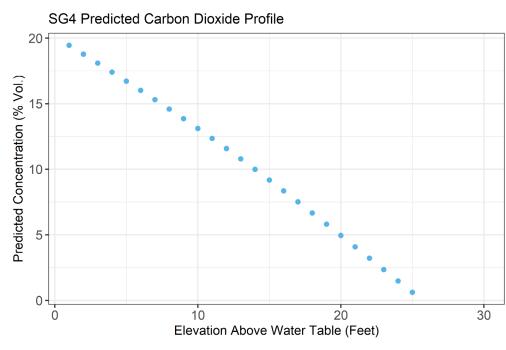


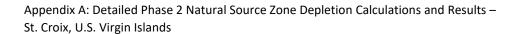














Attachment D Blank DCC Flux Measurements and Limit of Detection Calculation

Attachment D Blank DCC Flux Measurements and Limit of Detection Calculation Draft Phase 2 Natural Source Zone Depletion Assessment Report St. Croix Alumina Site St. Croix, U.S. Virgin Island

Location	Date				Temperatu	Dry CH ₄ Flux	Dry CH ₄ Flux (Exponenti	Dry CH₄ Flux	Dry CH₄ Flux (Linear	Dry CO ₂ Flux	Dry CO ₂ Flux (Exponenti	Dry CO ₂ Flux	Dry CO ₂ Flux (Linear
Location	Dute	Dry CH ₄	Dry CO ₂ μmol ⁺¹ mol ⁻¹	H ₂ O mmol ⁺¹ mol ⁻¹	re °C	fit) μmol·m ⁻² s ⁻¹	al fit)	(Linear fit)	fit)	fit)	al fit)	(Linear fit)	fit)
Blank	4/28/2022	1950.74	310.62	18.11	28.21	0.01	0.00	0.00	0.00	-0.04	0.00	-0.03	0.00
Blank	4/28/2022	1950.79	310.56	18.23	28.35	0.03	0.08	0.03	0.08	-0.01	0.00	-0.01	0.00
Blank	4/28/2022	1950.71	310.37	18.33	28.68	0.04	0.11	0.04	0.11	-0.09	0.02	-0.09	0.02
Blank	4/28/2022	1950.92	310.34	18.32	28.92	0.03	0.16	0.06	0.15	-0.04	0.01	-0.04	0.01
Blank	4/28/2022	1950.91	310.44	18.27	28.74	0.21	0.19	0.03	0.09	1.08	0.38	0.22	0.30
Blank	4/28/2022	1950.80	309.57	18.10	28.41	0.00	0.01	-0.04	0.10	-0.20	0.23	-0.20	0.23
Blank	4/28/2022	1950.87	310.48	18.28	29.13	0.05	0.00	0.01	0.00	-0.26	0.04	-0.12	0.05
Blank	4/28/2022	1950.98	310.10	18.31	29.14	0.13	0.40	0.11	0.38	0.36	0.35	0.31	0.34
Blank	4/28/2022	1951.01	310.33	18.25	29.30	0.12	0.24	0.01	0.01	-0.85	0.58	-0.45	0.58
Blank	4/28/2022	1951.29	309.57	18.12	28.77	0.00	0.01	0.03	0.14	1.10	0.41	0.34	0.35
Blank	4/28/2022	1951.09	309.09	18.03	28.36	0.00	0.01	0.01	0.02	0.03	0.01	0.03	0.01
Blank Blank	4/28/2022	1950.80	309.12	17.83	28.09	0.00	0.08	0.03	0.06	1.04	0.05	0.01	0.00
Blank	4/28/2022 4/28/2022	1950.66 1950.68	309.78 309.42	17.90 17.83	28.21 28.07	0.00 -0.03	0.00	-0.03	0.00	3.00 -1.26	0.08	-0.32	0.00
Blank	4/28/2022	1950.67	309.55	17.77	28.05	-0.03	0.00	-0.03	0.00	0.74	0.58	0.21	0.40
Blank	4/28/2022	1950.42	309.56	17.70	27.87	0.01	0.03	0.01	0.03	-0.07	0.04	-0.07	0.04
Blank	4/28/2022	1950.40	309.17	17.47	27.74	0.02	0.22	0.06	0.19	0.50	0.34	0.27	0.30
Blank	4/28/2022	1950.66	309.80	17.71	27.67	0.28	0.03	0.00	0.00	0.00	0.00	0.09	0.03
Blank	4/28/2022	1951.13	309.61	17.70	27.68	0.00	0.02	-0.08	0.29	-0.33	0.42	-0.24	0.39
Blank	4/28/2022	1950.93	310.02	17.86	28.27	0.60	0.31	0.00	0.00	1.76	0.38	0.21	0.19
Blank	4/28/2022	1951.01	309.60	17.91	28.39	0.00	0.00	0.07	0.23	0.25	0.31	0.25	0.31
Blank	4/28/2022	1951.11	309.96	18.03	28.65	-0.02	0.10	-0.02	0.10	-0.17	0.19	-0.17	0.19
Blank	4/28/2022	1951.07	310.07	18.15	28.69	0.08	0.17	0.03	0.07	0.07	0.26	0.20	0.23
Blank	4/28/2022	1951.10	310.52	18.29	28.58	0.05	0.20	0.06	0.20	0.00	0.00	0.00	0.00
Blank	4/28/2022	1950.99	311.32	18.38	28.28	-0.04	0.11	-0.04	0.11	-0.20	0.21	-0.20	0.21
Blank	4/28/2022	1950.97	310.69	18.37	28.19	0.04	0.14	0.04	0.14	0.71	0.01	0.05	0.01
Blank	4/28/2022	1951.08	310.27	18.29	28.21	-0.01	0.01	-0.01	0.01	-0.20	0.14	-0.20	0.14
Blank Blank	4/28/2022 4/28/2022	1951.01 1950.95	309.76 309.82	18.14 18.15	28.12 28.21	0.04 0.01	0.01	0.00 0.01	0.00	0.54 -0.01	0.55	0.52 -0.01	0.55 0.00
Blank	4/28/2022	1950.98	310.02	18.09	27.98	0.00	0.00	0.01	0.01	-0.01	0.00	-0.01	0.00
Blank	4/28/2022	1950.93	310.41	18.07	27.85	0.04	0.09	0.01	0.40	0.50	0.60	0.47	0.60
Blank	4/28/2022	1950.75	310.39	18.24	28.16	0.06	0.27	0.06	0.27	0.97	0.15	0.09	0.02
Blank	4/28/2022	1950.98	310.46	18.12	28.38	-0.04	0.10	-0.04	0.10	-0.22	0.19	-0.22	0.19
Blank	4/28/2022	1950.95	311.00	18.22	28.97	-0.01	0.00	-0.01	0.00	0.18	0.11	0.18	0.11
Blank	4/28/2022	1950.92	310.22	17.94	29.08	0.04	0.26	0.05	0.22	-0.15	0.15	-0.15	0.15
Blank	4/28/2022	1950.67	308.84	17.47	28.53	-0.01	0.01	-0.01	0.01	-0.20	0.31	-0.20	0.31
Blank	4/28/2022	1950.63	308.93	17.52	28.75	-0.01	0.02	-0.01	0.02	0.25	0.20	0.25	0.20
Blank	4/28/2022	1950.58	309.82	17.52	28.86	-0.01	0.00	-0.01	0.00	-0.01	0.01	-0.18	0.24
Blank	4/28/2022	1950.83	310.77	17.80	29.11	-0.01	0.02	-0.01	0.02	0.84	0.11	0.12	0.05
Blank	4/28/2022	1951.12	311.01	18.15	28.78	0.01	0.00	0.01	0.00	-8.32	0.38	-0.06	0.03
Blank Blank	4/28/2022 4/28/2022	1951.31 1951.30	311.04 310.96	18.39 18.37	28.67 28.31	0.01	0.03 0.16	0.01	0.03	-6.05 0.39	0.35 0.20	-0.17 0.13	0.14 0.15
Blank	4/28/2022	1951.06	310.80	18.17	28.41	0.07	0.16	0.03	0.15	-0.21	0.23	-0.21	0.13
Blank	4/28/2022	1950.99	310.82	18.16	28.48	0.04	0.13	0.03	0.03	-0.21	0.23	-0.21	0.23
Blank	4/28/2022	1951.15	311.27	18.36	28.50	-0.02	0.05	-0.02	0.05	1.22	0.17	0.17	0.07
Blank	4/28/2022	1951.02	311.14	18.39	28.77	0.37	0.13	0.01	0.01	-0.17	0.00	-0.05	0.01
Blank	4/28/2022	1951.31	311.39	18.33	28.33	0.08	0.26	0.08	0.26	0.27	0.15	0.27	0.15
Blank	4/28/2022	1951.34	311.88	18.34	28.09	-0.01	0.00	-0.01	0.00	0.59	0.00	0.00	0.00
Blank	4/28/2022	1951.33	311.57	18.30	27.86	0.57	0.37	0.02	0.04	0.01	0.02	0.57	0.51
Blank	4/28/2022	1951.28	311.36	18.33	27.96	0.00	0.00	0.00	0.00	-0.24	0.15	-0.24	0.15
Blank	4/28/2022	1951.09	310.60	18.15	27.81	-0.01	0.00	-0.01	0.00	-0.09	0.06	-0.09	0.06
Blank	4/28/2022	1951.12	310.89	18.28	28.02	0.15	0.26	0.06	0.18	0.03	0.00	0.02	0.00
Blank	4/28/2022	1951.25	310.69	18.29	27.98	0.26	0.03	0.00	0.00	-0.10	0.06	-0.10	0.06
Blank	4/28/2022	1951.31	310.94	18.20	27.83	0.01	0.00	0.01	0.00	0.97	0.22	0.16	0.12
Blank	4/28/2022	1951.21	310.60	18.17	27.82	-0.02	0.01	-0.01	0.01	0.23	0.36	0.24	0.37
Blank	4/28/2022	1950.92	309.83	18.00	27.73	-0.19	0.34	-0.06	0.34	-0.22	0.09	-0.24	0.09
Blank Blank	4/28/2022 4/28/2022	1950.93 1950.90	310.08 310.26	17.96 17.94	27.74 27.85	0.02	0.02	0.02 -0.04	0.03	-0.53 -0.09	0.47 0.05	-0.25 -0.09	0.29
Blank	4/28/2022	1950.90	310.26	17.94	27.85	0.00	0.01	-0.04	0.11	-0.09	0.05	-0.09	0.05
Blank	4/28/2022	1950.99	311.05	18.01	27.82	0.00	0.00	0.03	0.10	0.14	0.10	0.14	0.01
2.3	., 20, 2022	I			1	1		I.	3.20	1	3.23		3.20
	ean	1950.97	310.32	18.08	28.32	0.05		0.01		0.12		0.01	
	SD	0.22	0.69	0.25	0.43	0.13		0.04		0.43		0.21	
3>	SD	0.67	2.07	0.75	1.30	0.39	<u> </u>	0.11		1.28		0.64	<u> </u>

Notes:

Outlier values excluded from blank statistics.

 $\mu mol^{+1}mol^{-1}$ = micromole per mol

 $\mu mol \cdot m^{-2} s^{-1}$ = micromole per square meter per second

°C = degrees centigrade

 CH_4 = methane

CO₂ = carbon dioxide

DCC = dynamic closed chamber

 H_2O = water

 $mmol^{+1}mol^{-1} =$

nmol⁺¹mol⁻¹ = nanomole per mole

nmol·m⁻²s⁻¹ = nanomole per square meter per second

R² = regression coefficient

SD = standard deviation



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Attachment E Summary of Duplicate DCC Samples

Attachment E Summary of Duplicate DCC Samples Draft Phase 2 Natural Source Zone Depletion Assessment Report St. Croix Alumina Site St. Croix, U.S. Virgin Islands

Location	Ground Cover	Date	Start Time	Latitude	Longitude	Dry CH₄	Dry CO ₂	H ₂ O	Temperature	Dry CH ₄ Flux (Linear fit)	Dry CO ₂ Flux (Linear fit)	
					Longitude		· · · · · · · · · · · · · · · · · · ·	_	•	nmol·m ⁻² s ⁻¹	μmol·m ⁻² s ⁻¹	
DCC 3E	A a sa la a la		tern (Local) T		C4 770500	nmol·mol ⁻¹	μmol·mol ⁻¹	mmol·mol ⁻¹	°C		-	
DCC-25 DCC-25DUP	Asphalt	4/27/2022	10:58:54	17.710080	-64.770500	1963.43	377.95	20.17	31.80 32.30	-0.28	4.45 4.83	
DCC-25DUP	Asphalt	4/27/2022	11:04:41	17.710090	-64.770480	1963.41	380.37	20.45	32.30	-0.29 4%	4.83 8 %	
										4/0	670	
DCC-5	Grass	4/26/2022	11:43:57	17.712410	-64.771160	1946.08	436.29	19.76	37.12	-1.20	nd	
DCC-5	Grass	4/28/2022	10:33:54	17.712410	-64.771150	1950.84	323.07	18.85	31.99	-1.10	nd	
										8%	0%	
DCC-VW13B	Grass	4/28/2022	09:55:30	17.710480	-64.769890	1970.87	330.82	19.29	33.53	na	2.07	
DCC-VW13B-DUP	Grass	4/28/2022	10:01:57	17.710480	-64.769890	1960.31	331.01	19.67	32.86	na	2.09	
	5,000	,, = 0, = 0 = 0					552.52		5_100	na	1%	
		. / /									.=	
DCC-VW15-1	Asphalt	4/28/2022	09:24:51	17.711540	-64.770090	1969.45	376.56	18.56	31.97	-0.54	17.34	
DCC-VW15DUP	Asphalt	4/28/2022	14:52:22	17.711610	-64.770070	1949.92	374.82	17.97	32.48	-0.51	17.32	
										6%	0%	
DCC-VW18	Grass	4/27/2022	10:09:48	17.710660	-64.771120	1963.76	394.03	22.27	31.97	-1.28	8.00	
DCC-VW18DUP	Grass	4/27/2022	10:16:22	17.710650	-64.771120	1961.69	397.87	22.23	31.51	-1.33	8.20	
										4%	2%	
DCC-VW20	Cross	4/27/2022	09:30:08	17.711090	-64.772380	1962.47	387.41	23.82	32.23	-0.59	4.76	
DCC-VW20DUP	Grass Grass	4/27/2022	09:36:29	17.711090	-64.772380	1962.47	387.41	22.29	31.94	-0.59	4.76	
DCC-VW20D0P	Grass	4/2//2022	09.30.29	17.711090	-04.772360	1905.42	307.01	22.29	31.94	8%	0%	
										876	076	
DCC-VW24	Grass	4/26/2022	15:07:22	17.711490	-64.773050	1949.65	435.11	20.35	36.05	-0.71	nd	
DCC-VW24	Grass	4/28/2022	10:54:20	17.711480	-64.773060	1951.67	328.39	18.75	32.80	-0.78	1.28	
										9%	>100%	
DCC-VW31B	Grass	4/28/2022	11:06:14	17.709870	-64.775990	1955.48	335.78	19.22	32.18	-0.85	3.76	
DCC-VW31BDUP	Grass	4/28/2022	11:12:38	17.709870	-64.775990	1953.48	337.17	18.87	31.05	-0.90	3.95	
Dec VVS1BB01	Grass	4/20/2022	11.12.50	17.703070	04.773330	1552.07	337.17	10.07	31.03	5%	5%	
DCC-VW4	Grass	4/26/2022	08:28:40	17.711330	-64.768400	1944.70	472.10	20.30	31.46	-0.68	2.06	
DCC-VW4DUP	Grass	4/26/2022	08:34:18	17.711330	-64.768400	1944.44	455.47	20.09	31.00	-0.69	2.08	
										1%	1%	
DCC-VW4-2	Grass	4/26/2022	13:14:43	17.711350	-64.768390	1954.27	447.22	19.99	37.02	-0.80	1.30	
DCC-VW4-3	Grass	4/26/2022	16:40:27	17.711340	-64.768400	1958.10	446.58	21.60	31.50	-0.75	1.68	
										7%	26%	
DCC-VW5	Grass	4/26/2022	10:04:21	17.711620	-64.769440	1946.81	450.45	21.88	36.89	-0.74	2.39	
DCC-VW5	Grass	4/28/2022	09:44:32	17.711610	-64.769440	1971.97	337.38	19.17	33.34	-0.68	2.90	
		. · · · -		1		!	· · · · · · · · · · · · · · · · · · ·	<u> </u>	-	8%	19%	

Notes:

Bold percentage = relative percent difference $\mu mol \cdot m^{-2} s^{-1} = micromole \ per \ square \ meter \ per \ second$ $\mu mol \cdot mol^{-1} = micromole \ per \ mole$

°C = degrees centigrade CH₄ = methane

CO₂ = carbon dioxide

DUP = duplicate

H₂O = water mmol·mol⁻¹ = millimole per mole

na = not applicable; did not meet regression coefficient screening

nd = not detected

 $nmol \cdot m^{-2} s^{-1} = nanomole per square meter per second$

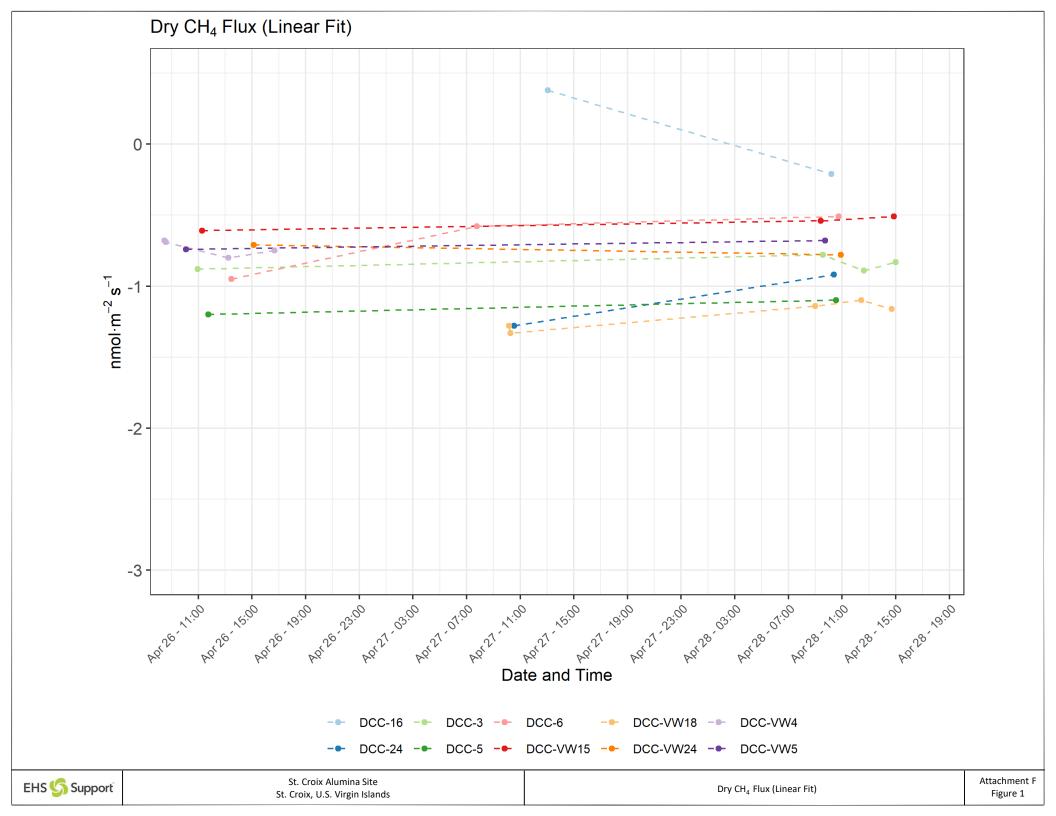
 $nmol \cdot mol^{-1} = nanomole per mole$

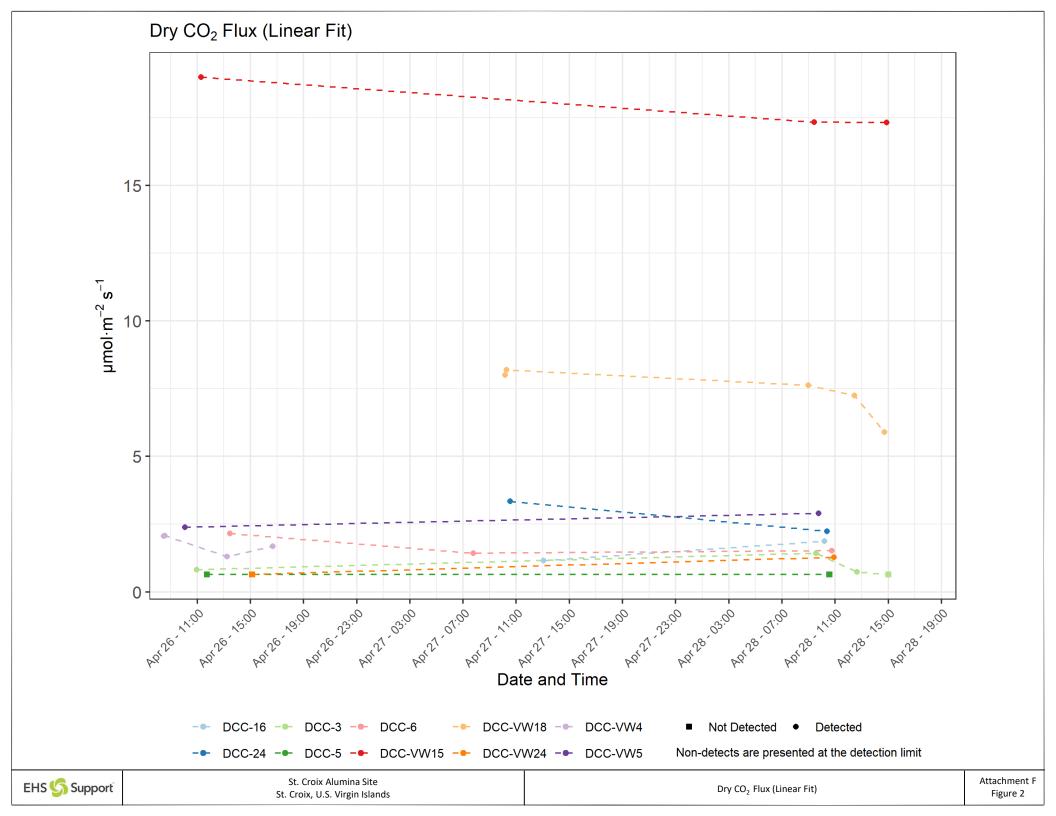
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Attachment F Summary of Temporal Replicate DCC Samples







Appendix B Updated LNAPL Recoverability/Mobility Assessment

Appendix B: LNAPL Recovery Data Evaluation St. Croix, U.S. Virgin Islands

Prepared for:

St. Croix Alumina Site

Prepared by:

EHS Support

August 2022



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Attachment A LNAPL Recovery Analysis



Acronyms

CSM Conceptual Site Model

DPPHC dissolved phase petroleum hydrocarbon constituents

ft² square feet gpd gallon per day

ITRC Interstate Technology & Regulatory Council

LNAPL light non-aqueous phase liquid NSZD natural source zone depletion

OLS ordinary least squares

PSPH phase separated petroleum hydrocarbons

R² correlation coefficient

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EHS Support LLC iii



1 Introduction

This document was prepared to support the results of a Phase 2 Natural Source Zone Depletion (NSZD) Study that addresses the phase separated petroleum hydrocarbons (PSPH) and dissolved phase petroleum hydrocarbon constituents (DPPHC) located beneath the St. Croix Alumina facility in St. Croix, U.S. Virgin Islands ("Site"; Figure B-1).

Using historical data and the data collected from this modified light non-aqueous phase liquid (LNAPL) recovery program, a detailed assessment of LNAPL recovery/mobility and chemistry data was completed and reported in the July 2020 LNAPL Conceptual Site Model (CSM) and Remedial Action Work Plan (EHS Support, 2020). This assessment demonstrated that the majority of LNAPL recovery wells have reached or are approaching a practicality endpoint. In addition, the CSM and Remedial Action Work Plan proposed shutdown criteria for active recovery wells (EHS Support, 2020). However, the report recommended that due to uncertainties and data gaps, recovery operations, including well maintenance and semiannual groundwater monitoring should continue.

The information herein constitutes an update to the previous LNAPL recovery/mobility assessment.



2 Recovery Data Evaluation

In the LNAPL CSM and Remedial Action Plan developed by EHS Support (2020), a detailed analysis of all historical LNAPL recovery data was completed from the inception of recovery actions through to May 30, 2020. This analysis included an assessment of LNAPL recovery rates and the use of the LNAPL reservoir/recovery decline curve analysis to assess theoretical LNAPL recovery volumes, as described by ITRC (2018). This analysis noted the presence of low recovery rates in a large number of wells (less than 1 gallon per day [gpd]), which is indicative of low LNAPL transmissivities, strong downward trends in LNAPL recovery rates from select recovery wells, and a high percentage of wells where most theoretical recoverable LNAPL has already been recovered (greater than 90 percent).

Based on this assessment, it was recommended that the operation of the solar sipper skimmers be continued in wells VW5, VW6, VW13, VW13B, VW14, VW20, VW20B, VW21B, VW23, VW24, VW29, VW31, and VW32. The additional data collection was designed to verify and validate the findings from the assessment discussed above, as well as to further optimize skimmer operation at these wells to aid in future review and analysis of data.

In accordance with the recommendations included in the Remedial Action Plan (EHS Support, 2020), these wells have been in operation continuously since the approval of the plan, with optimized LNAPL recovery activities to ensure oil and water cuts are maintained as high as possible to demonstrate efficient recovery.

The analysis in LNAPL CSM and Remedial Action Plan (EHS Support, 2020) was updated to leverage additional data through July 31, 2021, in the Phase 1 NSZD Report. Section 7.1 summarizes a further update that leverages LNAPL recovery data collected through May 31, 2022 (**Table B-1**). A technical memo of the supplemental analysis with supporting figures and tables is provided as **Attachment A**.

2.1 Data Analysis

In accordance with the preliminary decision logic diagram for LNAPL recovery wells (Figure 6-3 from LNAPL CSM and Remedial Action Plan [EHS Support, 2020], replicated in **Figure 2-1**), the key metrics used include:

- Observation of declining recovery rates
- Recovery of 90% of the potentially recoverable LNAPL volume as determined by recovery decline curve analysis
- LNAPL recovery rates of less than 1 gpd
- LNAPL transmissivities of less than 0.8 square feet (ft²)/day

To assist in the comparison, three key tables (Tables 5-5, 5-6, and 5-7) from the LNAPL CSM and Remedial Action Plan (EHS Support, 2020) have been updated and are provided later in this section.



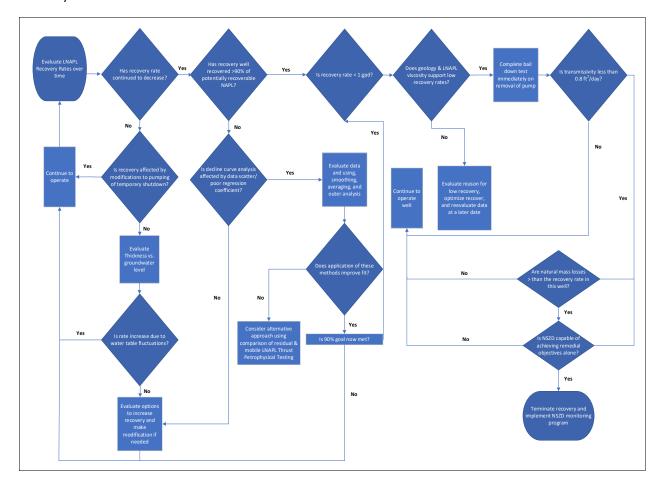
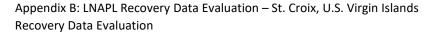


Figure 2-1 Decision logic criteria

Inclusion of new data and updates to the analysis methods (as described in the Reservoir Depletion Analysis Technical Memorandum [EHS Support, 2022]; provided in **Attachment A**) has generally improved the quality of fit. In general, the majority (10 of 14 wells) of recovery wells with solar sippers continue to exhibit declining LNAPL recovery volume trends over time (**Table 2-1**). Both the linear slope (ordinary least squares [OLS] Slope) and Theil-Sen slope are negative values indicating decreasing trends.

Table 2-1 Assessment of Recovery Trends for Wells with Solar Sippers Operating

Well	OLS Slope	OLS Intercept	R ²	OLS p- Value	Theil- Sen Slope	Theil- Sen Intercept	Kendall's Tau	Man- Kendall P-Value	Peak Recovery (gpd)	Latest Date >1 gpd
VW5	0.50	0.19	0.08	0.0606	0.39	0.18	0.17	0.1189	1.05	6/30/2020
VW6	-0.65	58.23	0.63	<0.0001	-0.38	35.56	-0.27	0.0004	114.01	5/31/2022
VW13	-0.31	28.66	0.37	<0.0001	-0.28	23.70	-0.41	<0.0001	98.93	5/31/2022
VW13B	-0.30	7.74	0.14	0.0022	-0.11	3.63	-0.12	0.1568	21.91	4/30/2022
VW14	-0.36	49.60	0.59	<0.0001	-0.26	35.17	-0.29	0.0001	87.37	5/31/2022





Well	OLS Slope	OLS Intercept	R²	OLS p- Value	Theil- Sen Slope	Theil- Sen Intercept	Kendall's Tau	Man- Kendall P-Value	Peak Recovery (gpd)	Latest Date >1 gpd
VW20	-0.13	9.60	0.09	0.0084	-0.21	10.89	-0.43	<0.0001	44.66	7/1/2013
VW20B	-0.36	24.61	0.25	<0.0001	-0.91	55.54	-0.43	<0.0001	61.17	7/1/2016
VW21B	-0.03	0.96	0.00	0.8133	-0.03	0.24	-0.17	0.1061	11.93	1/1/2017
VW23	0.88	0.06	0.07	0.1156	0.29	0.04	0.16	0.1569	0.58	PSPH Recovery Rate Never >1
VW24	-1.93	0.38	0.16	0.1141	-2.76	0.40	-0.48	0.0083	0.60	PSPH Recovery Rate Never > 1
VW29	-0.42	0.50	0.22	0.0004	-0.37	0.43	-0.22	0.0199	0.80	PSPH Recovery Rate Never >1
VW30	-0.19	0.10	0.03	0.3816	-0.31	0.12	-0.15	0.2901	0.18	PSPH Recovery Rate Never > 1
VW31	0.94	0.34	0.53	<0.0001	0.92	0.37	0.48	<0.0001	1.90	5/31/2022
VW32	0.94	0.13	0.46	<0.0001	0.95	0.10	0.47	<0.0001	0.78	PSPH Recovery Rate Never >1

Source: Table of EHS Support, (2020) amended.

Bold values indicate negative values with no decreasing trend.

gpd = gallons per day

OLS = ordinary least squares

PSPH = phase separated petroleum hydrocarbons

R² = correlation coefficient

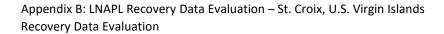
Comparison of the recovery well performance between the previously assessed periods of August 2018 to May 2020, June 2020 to the end of July 2021, and new data from August 2021 to May 2022 (**Table 2-2**) continues to demonstrate that recovery wells VW6, VW14, VW31, VW13B, and VW13 (in order of highest to lowest) continue to make up the top five wells for LNAPL recovery. The total recovery from these wells makes up 83.4 percent of the total volume recovered during the August 2021 to May 2022 period. Improvements in recovery rates were achieved in wells VW6 and VW31 over the revised period **Table B-1**).



Table 2-2 Comparison of Recovery Rates and Rankings for August 2018 to May 2020, June 2020 to July 2021, and August 2021 to May 2022

	Į.	August 2018-I	May 2020			June 2020-Ju	ıly 2021			August 2021	-May 202	2
Well	Total PSPH Recovered (gal)	Oil/Water Cut (%)	% of Total LNAPL	LNAPL Recovery Rank	Total PSPH Recovered (gal)	Oil/Water Cut (%)	% of Total LNAPL	LNAPL Recovery Rank	Total PSPH Recovered (gal)	Oil/Water Cut (%)	% of Total LNAPL	LNAPL Recovery Rank
VW2	19.12	39.19	0.42	15					34.70	41.03	1.34	10
VW4	0.81	5.41	0.02	22								
VW5	168.83	58.58	3.70	6	162.94	61.53	4.11	7	79.47	98.76	3.07	7
VW6	643.12	97.98	14.08	3	1033.57	94.95	26.10	1	797.25	95.59	30.81	1
VW7	1.60	44.44	0.04	20								
VW13	449.69	84.12	9.85	4	232.98	70.96	5.88	5	151.73	61.58	5.86	5
VW13B*	1197.10	0.14	26.21	1	704.71	0.13	17.79	3	238.70	0.30	9.23	4
VW14	923.69	99.78	20.23	2	869.02	97.53	21.94	2	635.21	90.54	24.55	2
VW15	6.12	20.72	0.13	17	44.09	22.40	1.11	11	54.30	39.05	2.10	8
VW18	16.06	11.79	0.35	16								
VW19	5.00	16.62	0.11	19								
VW20	99.69	86.71	2.18	11	62.59	48.07	1.58	8	18.25	30.24	0.71	12
VW20B	157.79	59.84	3.46	7	41.53	17.07	1.05	12	16.02	17.00	0.62	13
VW21	5.94	21.71	0.13	18	1.40	9.33	0.04	14				
VW21B	48.66	36.34	1.07	12	19.37	22.92	0.49	13	2.64	4.63	0.10	14
VW23	47.49	25.96	1.04	13	51.84	26.83	1.31	10	33.93	23.24	1.31	11
VW24	127.26	39.88	2.79	8								
VW29	113.62	41.86	2.49	10	56.76	21.00	1.43	9	49.99	28.86	1.93	9
VW30	34.67	17.81	0.76	14								
VW31	374.29	85.53	8.20	5	471.94	96.90	11.92	4	347.23	87.95	13.42	3
VW32	124.60	78.81	2.73	9	208.02	88.31	5.25	6	128.06	71.14	4.95	6
VW35	0.61	2.44	0.01	23								
VW38	1.00	16.39	0.02	21								

Source: Table 5-6 of EHS Support (2020) amended.





*Submersible pump installed: reported values account for water recovery from the submersible pump.

Non-operational wells are shaded gray.

Gal = gallons

LNAPL = light non-aqueous phase liquid

PSPH = phase separated petroleum hydrocarbons



Table 2-3 provides a preliminary assessment of the criteria contained within the decision logic diagram (**Figure 2-1**). Results from the table are summarized as follows:

- A total of 10 wells were identified as having decreasing recovery trends.
- Five of the wells with decreasing recovery trends (VW6, VW13, VW14, VW20, VW20B) have achieved greater than 90 percent of the theoretical LNAPL recovery volume and one well (VW24) is close to the 90 percent of theoretical LNAPL recovery volume.
- Of the six wells with decreasing trends that are near or above the 90 percent threshold, two
 wells had not recovered more than 1 gpd for a year (wells VW20 and VW20B) with well VW24
 never having recovered more than 1 gpd of LNAPL.

Several recovery wells (are VW5, VW23, VW24, VW29, VW30, and VW32) have very low total cumulative recovery (less than 1000 gallons) and very low recovery rates (less than 1 gpd). Many of these wells have never recovered more than 1 gpd of LNAPL and include wells with both increasing or decreasing recovery trends; many of the increasing trends were identified as statistical anomalies.

Table 2-3 Assessment of Recovery Trends

Well	Cumulative PSPH Recovered to May 2022 (Thousands of Gallons)	Theoretical Maximum (Thousands of Gallons)	% of Theoretical Maximum Recovered	Decreasing Thiel-Sen Trend?	Last Date LNAPL Recovery Rate > 1 gpd
VW5	0.411	na	na	No	6/30/2020
VW6	88.564	92.571	95.67	Yes	5/31/2022
VW13	84.182	85.771	98.15	Yes	5/31/2022
VW13B	20.387	32.519	62.69	Yes	4/30/2022
VW14	128.107	133.535	95.94	Yes	5/31/2022
VW20	52.163	52.729	98.93	Yes	7/1/2013
VW20B	61.151	61.223	99.88	Yes	7/1/2016
VW21B	6.370	8.513	74.83	Yes	1/1/2017
VW23	0.133	na	na	No	PSPH Recovery Rate Never > 1
VW24	0.127	0.144	88.47	Yes	PSPH Recovery Rate Never > 1
VW29	0.892	1.161	76.82	Yes	PSPH Recovery Rate Never > 1
VW30	0.196	0.391	50.24	Yes	PSPH Recovery Rate Never > 1
VW31	1.193	na	na	No	5/31/2022
VW32	0.461	na	na	No	PSPH Recovery Rate Never > 1

Source: Table 5-7 of EHS Support (2020) amended.

Yellow highlight indicates decision logic criteria have been met.

gpd = gallons per day

LNAPL = light non-aqueous phase liquid

na = not assessed due to the direction of the trend.

Appendix B: LNAPL Recovery Data Evaluation – St. Croix, U.S. Virgin Islands Recovery Data Evaluation



PSPH = phase separated petroleum hydrocarbons

Based on this assessment, most of the recovery wells likely meet the shutdown criteria proposed for the Site. The final step in the evaluation process (**Figure 2-1**) was the completion of the Phase 2 NSZD assessment described in this report. Decision logic criteria state that where robust NSZD processes are identified and mass losses are quantified to be larger than LNAPL recovery rates, a recommendation will be provided to transition away from active LNAPL recovery. As indicated on **Figure B-3**, natural mass losses exceed LNAPL recovery rates Site-wide, and at all specific locations except VW6 and VW14.

Appendix B: LNAPL Recovery Data Evaluation – St. Croix, U.S. Virgin Islands Findings and Recommendations



3 Findings and Recommendations

Findings and recommendations of this LNAPL recovery assessment include:

- 1. The re-analysis of the recovery data indicates that most wells have met the triggers contained in the decision logic diagrams. New statistical methods have improved the fit and aided in demonstrating we have met the 90 percent recovery threshold in five wells, and three wells (VW24, VW21B, and VW29) are close to approaching the 90 percent threshold.
- Preliminary assessment (as noted above) demonstrates that NSZD rates exceed mass removal
 through active LNAPL recovery. Active recovery is providing limited benefits and termination of
 active LNAPL recovery operations is recommended at wells VW5, VW20, VW20B, VW21B,
 VW23, VW24, VW29, VW30, VW32 (as documented in Table 2-1) given that the Phase 2 NSZD
 results confirm that NSZD losses are much greater than what can be currently recovered.

Appendix B: LNAPL Recovery Data Evaluation – St. Croix, U.S. Virgin Islands References



4 References

- EHS Support. (2020). LNAPL CSM and Remedial Action Work Plan. St. Croix Alumina Site, St. Croix, U. S. Virgin Islands. July.
- EHS Support. (2022). Reservoir Depletion Analysis Technical Memorandum. St. Croix Alumina Site, St. Croix, U. S. Virgin Islands. June.
- ITRC. (2018). Light non-aqueous phase liquids (LNAPL) document update, LNAPL-3, Interstate Technology & Regulatory Council, LNAPL Update Team, Washington, USA.



Tables

PSPH Recovery Summary August 2018 - May 2022 Draft Phase 2 Natural Source Zone Depletion Assessment Report St. Croix Alumina Site

						, U.S. Vilgili isia						
	Reporting P	Period: 8/24/2018	3-10/5/2018	Reporting Pe	eriod: 10/6/2018	-10/31/2018	Reporting Pe	eriod: 11/1/2018	11/30/2018	Reporting Pe	eriod: 12/1/2018	-12/28/2018
Well	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)
VW2		0.227	0.237	0.024	0.681	<u>0.704</u>						
VW4							0.027	0.475	0.502			
VW5	0.071	0.355	0.426	0.000	0.157	0.157						
VW6	<u>0.663</u>	0.024	0.687	1.058	0.078	1.136	0.747	0.340	1.086	0.632	0.000	0.632
VW7										0.057	0.071	0.129
VW13	<u>0.805</u>	0.379	1.184	0.470	1.058	1.528	0.068	0.000	0.068	0.457	0.015	0.472
VW13B*		0.000	0.000	5.731	1711.192	1716.923	1.000	302.333	303.333	4.750	1423.821	1428.571
VW14	<u>0.554</u>	0.000	<u>0.554</u>	0.337	0.000	0.337	0.475	0.068	0.543	0.618	0.000	<u>0.618</u>
VW15	0.024	0.142	0.166									
VW18	0.071	0.379	0.450				0.014	0.000	0.014	0.014	0.029	0.043
VW19							0.007	0.000	0.007	0.021	<u>0.575</u>	<u>0.596</u>
VW20				<u>0.611</u>	<u>0.588</u>	1.199						
VW20B	0.379	0.332	<u>0.711</u>	<u>0.940</u>	<u>0.862</u>	1.802	0.272	1.154	1.426	0.350	0.014	0.364
VW21	0.057	0.047	0.104									
VW21B				0.118	0.039	0.157						
VW23	0.071	<u>0.568</u>	<u>0.640</u>				0.068	0.000	0.068	0.146	0.000	0.146
VW24	0.322	0.426	<u>0.748</u>	0.329	<u>0.705</u>	1.034	0.095	0.272	0.367	0.364	0.364	<u>0.729</u>
VW29				0.118	0.000	0.118	0.306	0.238	<u>0.543</u>	0.071	0.000	0.071
VW30	0.024	0.332	0.355	0.094	1.136	1.230	0.020	0.000	0.020	0.079	0.014	0.093
VW31	0.355	0.000	0.355	0.447	0.000	0.447	0.183	1.650	1.833	<u>0.568</u>	0.000	<u>0.568</u>
VW32										0.014	0.000	0.014
VW35							0.020	<u>0.815</u>	<u>0.835</u>			
VW38												
Period Total (gal)	146.05	138.11	284.57	256.87	42912.39	43169.25	99.05	9220.33	9319.38	228.00	39897.31	40125.31



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St. Croix Alumina Site

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	Reporting F	Period: 1/1/2019	-1/31/2019	Reporting I	Period: 2/1/2019	-2/28/2019	Reporting P	Period: 3/01/2019	9-3/31/2019	Reporting	Period: 4/1/2019	-4/30/2019
Well	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)
VW2	0.006	0.006	0.013				0.100	0.000	0.100	0.210	0.000	0.210
VW4												
VW5	0.097	0.000	0.097	0.246	0.000	0.246	0.368	0.000	0.368	0.413	0.000	0.413
VW6	1.116	0.000	1.116	0.800	0.000	0.800	1.445	0.000	1.445	1.290	0.000	1.290
VW7										0.000	0.000	0.000
VW13	0.894	0.013	0.906	<u>0.511</u>	0.000	0.511	0.723	0.000	0.723	0.813	0.000	0.813
VW13B*	0.000	1496.839	1496.839	0.000	1457.100	1457.100	0.000	1319.342	1319.342	6.963	893.080	900.043
VW14	1.103	0.000	1.103	<u>0.728</u>	0.000	<u>0.728</u>	0.657	0.000	<u>0.657</u>	1.990	0.000	1.990
VW15												
VW18				0.036	0.125	0.161						
VW19							0.065	0.000	0.065			
VW20	0.145	0.000	0.145	0.364	0.000	0.364	0.361	0.000	0.361	0.340	0.000	0.340
VW20B	<u>0.565</u>	0.013	<u>0.577</u>	0.086	0.261	0.346				0.123	0.000	0.123
VW21	0.113	0.494	<u>0.606</u>									
VW21B	0.165	0.165	0.329	0.218	0.000	0.218	0.242	0.297	<u>0.539</u>	0.170	0.340	<u>0.510</u>
VW23				0.029	0.071	0.100						
VW24	<u>0.532</u>	0.329	<u>0.861</u>				0.165	<u>0.526</u>	<u>0.690</u>	0.143	<u>0.543</u>	<u>0.687</u>
VW29	0.210	0.000	0.210	0.289	0.000	0.289	0.261	0.000	0.261	0.237	0.000	0.237
VW30				0.036	0.036	0.071				0.073	1.003	1.077
VW31	<u>1.000</u>	0.000	<u>1.000</u>	0.436	0.000	0.436	<u>0.526</u>	0.000	<u>0.526</u>	0.477	0.000	0.477
VW32				0.071	0.000	0.071	0.106	0.000	0.106	0.053	0.000	0.053
VW35												
VW38							0.032	0.165	0.197			
Period Total (gal)	184.30	46433.60	46617.90	107.77	40812.60	40920.37	156.57	40930.20	41086.77	398.90	26849.00	27247.90



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	Reporting I	Period: 5/1/2019	-5/31/2019	Reporting I	Period: 6/1/2019	-6/30/2019	Reporting I	Period: 7/1/2019	-7/31/2019	Reporting I	Period: 8/1/2019	-8/31/2019
Well	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)
VW2	0.077	0.000	0.077	0.203	0.067	0.270						
VW4												
VW5	0.165	0.000	0.165	0.373	0.137	<u>0.510</u>	0.197	0.000	0.197	0.374	0.184	<u>0.558</u>
VW6	1.513	0.000	1.513	1.223	0.000	1.223				<u>0.590</u>	0.000	0.590
VW7												
VW13	1.545	0.000	1.545	0.813	0.000	0.813	<u>0.590</u>	0.000	0.590	<u>0.626</u>	0.000	<u>0.626</u>
VW13B*	6.516	774.129	780.645	2.600	777.400	780.000	1.184	569.623	570.806	<u>0.787</u>	1849.387	1850.174
VW14	1.545	0.000	1.545	0.340	0.000	0.340	2.432	0.000	2.432	<u>0.952</u>	0.000	<u>0.952</u>
VW15							0.000	0.000	0.000	0.000	0.000	0.000
VW18							0.065	0.494	<u>0.558</u>	0.065	0.032	0.097
VW19							0.071	0.290	0.361	0.000		
VW20	0.177	0.000	0.177	0.307	0.000	0.307				0.000		
VW20B	0.229	0.032	0.261	0.440	0.137	<u>0.577</u>	0.197	0.065	0.261	0.229	0.132	0.361
VW21				0.000	0.137	0.137				0.000		
VW21B	0.132	0.329	0.461	0.170	<u>0.780</u>	<u>0.950</u>				0.000		
VW23							0.045	0.229	0.274	0.000	0.248	0.248
VW24	0.229	0.100	0.329	<u>0.577</u>	<u>0.610</u>	1.187	0.229	0.132	0.361	0.100	0.000	0.100
VW29	0.132	0.000	0.132	0.270	0.340	<u>0.610</u>	0.032	0.000	0.032	0.065	0.065	0.129
VW30	0.106	<u>0.616</u>	<u>0.723</u>	0.170	<u>0.680</u>	<u>0.850</u>	0.100	0.000	0.100	0.045	0.013	0.058
VW31	0.439	0.000	0.439	<u>0.610</u>	0.067	<u>0.677</u>	0.368	0.000	0.368	0.387	0.000	0.387
VW32	0.077	0.000	0.077	0.137	0.067	0.203	0.065	0.000	0.065	0.013	0.032	0.045
VW35												
VW38												
Period Total (gal)	399.40	24031.40	24430.80	247.00	23412.60	23659.60	172.80	17695.80	17868.60	131.20	57352.90	57484.10



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	Reporting F	Period: 9/1/2019-	-9/30/2019	Reporting Pe	eriod: 10/1/2019	-10/31/2019	Reporting Po	eriod: 11/1/2019	-11/30/2019	Reporting Po	eriod: 12/1/2019	-12/31/2019
Well	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)
VW2												
VW4												
VW5	0.440	0.137	<u>0.577</u>	0.177	<u>0.513</u>	<u>0.690</u>	0.117	<u>0.577</u>	<u>0.693</u>	0.119	1.116	1.235
VW6	<u>0.543</u>	0.000	<u>0.543</u>				0.340	0.000	0.340	1.316	0.000	1.316
VW7												
VW13	1.357	0.067	1.423	<u>0.787</u>	0.197	<u>0.984</u>	0.097	<u>0.733</u>	<u>0.830</u>	<u>0.690</u>	0.329	1.019
VW13B*	1.663	2238.633	2240.297	<u>0.658</u>	1517.813	1518.471	0.477	1696.283	1696.760	<u>0.855</u>	1960.877	1961.732
VW14	1.243	0.000	1.243	2.235	0.000	2.235	1.187	0.000	1.187	2.432	0.000	2.432
VW15	0.000	0.000	0.000				0.000	0.000	0.000			
VW18	0.033	1.153	1.187	0.019	0.113	0.132	0.067	0.237	0.303	0.052	0.145	0.197
VW19												
VW20												
VW20B	0.103	0.000	0.103	0.165	0.000	0.165	0.203	0.000	0.203	0.297	0.000	0.297
VW21												
VW21B												
VW23	0.033	1.160	1.193	0.139	0.374	<u>0.513</u>	0.237	0.387	<u>0.623</u>	0.032	0.426	0.458
VW24	<u>0.510</u>	0.103	<u>0.613</u>	0.094	<u>0.545</u>	<u>0.639</u>	0.073	<u>0.693</u>	<u>0.767</u>	0.255	<u>0.632</u>	<u>0.887</u>
VW29	0.170	1.153	1.323	0.132	<u>0.658</u>	<u>0.790</u>	0.103	<u>0.793</u>	<u>0.897</u>	0.177	<u>0.842</u>	1.019
VW30	0.087	0.257	0.343	0.145	0.229	0.374	0.053	0.320	0.373			
VW31	1.087	0.000	1.087	0.394	0.000	0.394	0.183	0.190	0.373	0.329	0.000	0.329
VW32				0.248	0.065	0.313	0.123	0.170	0.293	0.439	<u>0.755</u>	1.194
VW35												
VW38												
Period Total (gal)	218.10	67279.90	67498.00	161.00	47135.70	47296.70	97.80	51011.50	51109.30	216.80	60918.80	61135.60



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	Reporting I	Period: 1/1/2020	-1/31/2020	Reporting I	Period: 2/1/2020	-2/29/2020	Reporting	Period: 3/1/2020	-3/31/2020	Reporting I	Period: 4/1/2020	-4/30/2020
Well	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)
VW2												
VW4												
VW5	0.197	0.329	<u>0.526</u>	0.455	0.000	0.455	<u>0.657</u>	0.197	<u>0.854</u>	0.270	0.067	0.337
VW6	1.381	0.000	1.381	1.159	0.000	1.159	1.806	0.000	1.806	1.730	0.000	1.730
VW7												
VW13	0.361	0.000	0.361	<u>0.576</u>	0.000	<u>0.576</u>	<u>0.842</u>	0.000	0.842	0.917	0.000	<u>0.917</u>
VW13B*	1.116	1540.452	1541.568	1.300	1455.517	1456.817	1.577	1399.613	1401.190	2.273	2174.200	2176.473
VW14	2.071	0.000	2.071	2.107	0.000	2.107	2.465	0.000	2.465	2.173	0.000	2.173
VW15							0.000					
VW18							0.065	<u>0.623</u>	0.687	0.000	0.477	0.477
VW19												
VW20	0.113	0.000	0.113	0.386	0.000	0.386	0.229	0.000	0.229	0.203	0.000	0.203
VW20B	0.132	0.000	0.132	0.107	0.107	0.214	0.165	0.261	0.426	0.103	0.103	0.207
VW21												
VW21B							0.261	<u>0.658</u>	0.919	0.137	0.000	0.137
VW23	0.132	0.329	0.461	0.069	0.000	0.069	0.229	0.229	0.458	0.237	0.067	0.303
VW24	0.065	0.261	0.326	0.034	0.000	0.034	0.000	0.000	0.000			
VW29	0.032	<u>0.558</u>	<u>0.590</u>	0.245	0.107	0.352	0.329	0.065	0.394	0.373	0.033	0.407
VW30	0.084	0.394	0.477	0.034	0.283	0.317						
VW31	<u>0.558</u>	0.197	<u>0.755</u>	<u>0.983</u>	0.000	<u>0.983</u>	<u>0.952</u>	0.000	<u>0.952</u>	1.120	0.000	1.120
VW32	0.426	0.000	0.426	0.279	0.000	0.279	<u>0.690</u>	0.000	<u>0.690</u>	<u>0.813</u>	0.000	<u>0.813</u>
VW35												
VW38												
Period Total (gal)	206.70	47818.10	48024.80	224.30	42224.40	42448.70	318.27	43451.00	43769.27	310.50	65248.40	65558.90



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	Reporting F	Period: 5/1/2020	-5/31/2020	Reporting F	Period: 6/1/2020	-6/30/2020	Reporting	g Period: 7/1/2020	-7/31/2020	Reporting	Period: 8/1/2020-	8/31/2020
Well	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)
VW2												
VW4												
VW5	<u>0.787</u>	0.000	<u>0.787</u>	1.053		1.053	1.019		1.019	0.494		0.494
VW6	1.710	0.000	1.710	1.527		1.527	1.477		1.477	1.655		1.655
VW7												
VW13	<u>0.590</u>		<u>0.590</u>	<u>0.780</u>	0.203	<u>0.983</u>	<u>0.755</u>	0.197	<u>0.952</u>	<u>0.626</u>		<u>0.626</u>
VW13B*	1.116	1728.839	1729.955	1.767	0.250	2.017	1.710	0.242	1.952	1.610	910.913	912.523
VW14	2.497		2.497	2.003		2.003	1.939		1.939	1.710	0.000	1.710
VW15	0.165	<u>0.558</u>	<u>0.723</u>	0.307	0.203	<u>0.510</u>	0.297	0.197	0.494	0.032	0.394	0.426
VW18												
VW19												
VW20	0.165		0.165	0.067	<u>0.983</u>	1.050	0.065	<u>0.952</u>	1.016	0.077	0.165	0.242
VW20B	0.100	0.032	0.132	0.033	<u>0.647</u>	<u>0.680</u>	0.032	<u>0.626</u>	<u>0.658</u>	0.197	0.000	0.197
VW21			0.000	0.033	0.453	0.487	0.032	0.439	0.471			
VW21B	0.013	0.184	0.197	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
VW23	0.077	0.119	0.197	0.040	0.130	0.170	0.039	0.126	0.165	0.032	0.426	0.458
VW24												
VW29	0.229	0.329	<u>0.558</u>	0.103	<u>0.950</u>	1.053	0.100	<u>0.919</u>	1.019	0.084	<u>0.626</u>	<u>0.710</u>
VW30												
VW31	<u>0.887</u>		<u>0.887</u>	1.187	0.000	1.187	1.148	0.000	1.148	<u>0.658</u>	0.000	<u>0.658</u>
VW32	<u>0.526</u>		<u>0.526</u>	<u>0.780</u>	0.137	<u>0.917</u>	<u>0.755</u>	0.132	<u>0.887</u>	0.361	0.000	0.361
VW35												
VW38												
Period Total (gal)	274.70	53631.90	53906.60	290.40	118.70	409.10	283.10	36003.60	36282.70	233.60	28288.20	28521.80



PSPH Recovery Summary August 2018 - May 2022 Draft Phase 2 Natural Source Zone Depletion Assessment Report

St. Croix Alumina Site

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	Reporting	Period: 9/1/2020-	9/30/2020	Reporting P	eriod: 10/1/2020-	10/31/2020	Reporting Pe	eriod: 11/1/2020	/11/30/2020	Reporting P	eriod: 12/1/2020	-12/31/2020
Well	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)
VW2												
VW4												
VW5	0.440	0.407	0.847	0.013	<u>0.578</u>	0.591	0.088	1.711	1.799	0.276		0.276
VW6	3.923	0.000	3.923	1.446	0.460	1.906	2.309	1.358	3.667	1.881		1.881
VW7												
VW13	<u>0.577</u>	0.273	<u>0.850</u>	0.191	0.342	<u>0.532</u>	0.210	0.394	<u>0.604</u>	0.256		0.256
VW13B*	2.750	933.827	936.577	1.248	1838.777	1840.026	2.580	1820.883	1823.463	1.881	1656.968	1658.849
VW14	4.277	0.000	4.277	2.103		2.103	3.395	0.136	3.531	1.649		1.649
VW15	0.103	0.407	<u>0.510</u>	0.066	0.033	0.099	0.204	0.306	<u>0.509</u>	0.171	0.342	<u>0.513</u>
VW18												
VW19												
VW20	0.053	0.217	0.270	0.020	0.138	0.158	0.238	0.061	0.299	0.046	0.131	0.177
VW20B	0.013	0.103	0.117	0.046	<u>0.578</u>	<u>0.624</u>	0.136	1.154	1.290	0.072	0.125	0.197
VW21												
VW21B	0.000	0.000	0.000	0.007	0.125	0.131	0.061	0.414	0.475	0.013	0.499	<u>0.513</u>
VW23	0.047	<u>0.610</u>	<u>0.657</u>	0.007	0.394	0.401	0.129	<u>0.611</u>	<u>0.740</u>	0.105	0.407	<u>0.513</u>
VW24												
VW29	0.080	<u>0.577</u>	<u>0.657</u>	0.039	0.026	0.066	0.041	0.163	0.204	0.000	0.092	0.092
VW30												
VW31	1.087	0.000	1.087	<u>0.854</u>	0.000	<u>0.854</u>	1.086	0.204	1.290	<u>0.723</u>		<u>0.723</u>
VW32	<u>0.647</u>	0.000	<u>0.647</u>	0.394	<u>0.519</u>	<u>0.913</u>	<u>0.645</u>	0.075	<u>0.720</u>	<u>0.519</u>		<u>0.519</u>
VW35												
VW38												
Period Total (gal)	419.90	28092.60	28512.50	199.40	57101.10	57300.50	333.70	54824.10	55157.70	235.40	51415.50	51650.90



PSPH Recovery Summary August 2018 - May 2022 Draft Phase 2 Natural Source Zone Depletion Assessment Report

St. Croix Alumina Site

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	Reporting Period: 1/1/2021-1/31/2021			Reporting	Reporting Period: 2/1/2021-2/28/2021 Re			Reporting Period: 3/1/2021-3/31/2021			Reporting Period: 4/1/2021-4/31/2021		
Well	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	
VW2													
VW4													
VW5	<u>0.545</u>		0.545	<u>0.546</u>		0.546	0.276		0.276	0.462		0.462	
VW6	2.460		2.460	2.627		2.627	2.691		2.691	2.542		2.542	
VW7													
VW13	0.467		0.467	0.364		0.364	0.407		0.407	0.373		0.373	
VW13B*	<u>0.868</u>	1327.742	1328.610	1.281	2041.500	2042.781	1.447	1215.290	1216.737	1.555	1517.600	1519.155	
VW14	1.100	0.000	1.100	1.666		1.666	1.678		1.678	1.346		1.346	
VW15		<u>0.611</u>	0.611	0.073	0.437	0.509		0.493	0.493	0.014	<u>0.611</u>	<u>0.625</u>	
VW18													
VW19													
VW20	0.217	0.033	0.250	0.255		0.255	0.263		0.263	0.170		0.170	
VW20B	0.059	0.039	0.099	0.022	0.015	0.036	0.079	0.414	0.493	0.081	<u>0.801</u>	<u>0.883</u>	
VW21													
VW21B		<u>0.670</u>	<u>0.670</u>	0.218	0.160	0.378	0.053		0.053	0.054		0.054	
VW23	0.026	0.053	0.079	0.073	0.146	0.218	0.329		0.329	0.136		0.136	
VW24													
VW29		0.204	0.204	0.255	<u>0.509</u>	<u>0.764</u>	0.230	<u>0.657</u>	<u>0.887</u>	0.068	<u>0.713</u>	<u>0.781</u>	
VW30													
VW31	1.013		1.013	1.249		1.249	1.128		1.128	<u>0.897</u>		<u>0.897</u>	
VW32	0.434		0.434	0.473		0.473	0.493		0.493	0.455		0.455	
VW35													
VW38													
Period Total (gal)	222.82	41209.91	41432.73	254.80	57197.40	57452.30	281.28	37722.48	38003.76	244.55	45591.76	45836.31	



PSPH Recovery Summary August 2018 - May 2022 Draft Phase 2 Natural Source Zone Depletion Assessment Report St. Croix Alumina Site

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	Reporting I	Period: 5/1/2021	-5/31/2021	Reporting I	Period: 6/1/2021	-6/30/2021	Reporting I	Period: 7/1/2021	-7/31/2021	Reporting	Period: 8/1/2021-	8/31/2021
Well	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)
VW2												
VW4												
VW5	0.374		0.374	0.428		0.428	0.329		0.329	0.394		0.394
VW6	3.184		3.184	2.691		2.691	3.097		3.097	2.545		2.545
VW7												
VW13	0.952		0.952	0.985	0.272	1.256	0.965	1.300	2.265	0.329	0.261	0.590
VW13B*	2.171	1503.819	1505.990	0.897	763.095	763.992	1.303	842.748	844.052	0.435	1086.871	1087.306
VW14	1.881		1.881	1.645		1.645	1.590	<u>0.577</u>	2.168	1.390		1.390
VW15	0.019	0.132	0.152				0.329	0.394	<u>0.723</u>	0.165	0.329	0.494
VW18												
VW19												
VW20	0.297		0.297	0.238		0.238	0.065	0.100	0.165	0.132	0.132	0.265
VW20B	0.152	<u>0.703</u>	<u>0.855</u>	0.102	<u>0.645</u>	<u>0.747</u>	0.132	<u>0.735</u>	<u>0.868</u>	0.171	<u>0.703</u>	<u>0.874</u>
VW21												
VW21B	0.113		0.113	0.102		0.102	0.032	0.261	0.294	0.019	<u>0.506</u>	<u>0.526</u>
VW23	0.494	0.032	<u>0.526</u>	0.170	0.475	<u>0.645</u>	0.045	<u>0.690</u>	<u>0.735</u>	0.006	0.439	0.445
VW24												
VW29	0.481	0.242	<u>0.723</u>	0.217	<u>0.699</u>	<u>0.917</u>	0.065	<u>0.855</u>	<u>0.919</u>	0.084	0.177	0.261
VW30												
VW31	1.677		1.677	1.256	0.000	1.256	1.590	0.290	1.881	1.303		1.303
VW32	<u>0.545</u>		<u>0.545</u>	0.441	0.000	0.441	0.271		0.271	0.323		0.323
VW35												
VW38												
Period Total (gal)	382.50	46652.80	47035.30	275.10	22955.60	23230.70	304.20	26286.50	26590.70	226.20	33772.00	33998.20



PSPH Recovery Summary August 2018 - May 2022 Draft Phase 2 Natural Source Zone Depletion Assessment Report

St. Croix Alumina Site

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Well	Reporting	Period: 9/1/2021-	9/30/2021	Reporting P	Period: 10/1/2021-	10/31/2021	Reporting P	Period: 11/1/2021-	11/30/2021	Reporting F	12/31/2021	
	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)
VW2							0.006	0.329	0.335	0.171	0.499	0.670
VW4												
VW5	0.099		0.099	0.100		0.100	0.019		0.019	<u>0.513</u>		<u>0.513</u>
VW6	2.749		2.749	2.458	<u>0.752</u>	3.210	1.852	0.289	2.141	2.633	0.145	2.778
VW7												
VW13	0.460	0.131	<u>0.591</u>	0.261	1.116	1.377				0.118		0.118
VW13B*	0.434	1446.481	1446.915	<u>0.926</u>	1.563	2.488				<u>0.608</u>		<u>0.608</u>
VW14	<u>0.637</u>	0.289	<u>0.926</u>	1.736	1.563	3.299	2.345	0.116	2.461	2.373	0.174	2.546
VW15	0.263	0.296	<u>0.559</u>	0.361	0.131	0.493	0.255	0.152	0.406	0.269	0.020	0.289
VW18												
VW19												
VW20	0.066	0.230	0.296	0.013	0.217	0.230		0.261	0.261	0.026	0.092	0.118
VW20B	0.026	<u>0.894</u>	<u>0.920</u>	0.007	<u>0.506</u>	<u>0.513</u>		0.223	0.223			
VW21												
VW21B	0.046	<u>0.513</u>	<u>0.559</u>	0.020	0.473	0.493		0.261	0.261			
VW23	0.079	0.283	0.361	0.053	0.309	0.361	0.019	0.322	0.341	0.099	0.302	0.401
VW24												
VW29	0.112	0.217	0.329	0.118	0.440	<u>0.559</u>	0.100	0.335	0.435	0.099	0.309	0.407
VW30												
VW31	<u>0.868</u>	1.013	1.881	1.157		1.157	<u>0.606</u>	0.087	<u>0.694</u>	<u>0.550</u>		<u>0.550</u>
VW32	0.394		0.394	0.164	0.099	0.263	0.355	<u>0.532</u>	<u>0.887</u>	0.440	0.026	0.466
VW35												
VW38												
Period Total (gal)	193.18	44960.72	45153.90	228.62	222.20	450.82	172.30	90.20	262.50	244.90	48.60	293.40



PSPH Recovery Summary August 2018 - May 2022 Draft Phase 2 Natural Source Zone Depletion Assessment Report

St. Croix Alumina Site

	Reporting	Period: 1/1/2022-	1/31/2022	Reporting	Period: 2/1/2022-	2/28/2022	Reporting	Period: 3/1/2022-	2-3/31/2022 Reporting Period: 4/1/2022-4/30/2022			4/30/2022	
Well	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	
VW2	0.381	<u>0.584</u>	<u>0.965</u>	0.132	0.197	0.329	0.165		0.165	0.132			
VW4													
VW5	<u>0.761</u>		<u>0.761</u>	0.381		0.381	0.132		0.132	0.020		0.020	
VW6	3.068		3.068	2.458		2.458	2.458		2.458	2.981		2.981	
VW7													
VW13	<u>0.571</u>	<u>0.855</u>	1.426	<u>0.690</u>	<u>0.626</u>	1.316	<u>0.919</u>	0.065	<u>0.984</u>	<u>0.723</u>		<u>0.723</u>	
VW13B*	1.532		1.532	1.448		1.448	1.013		1.013	1.013		1.013	
VW14	3.242		3.242	2.316		2.316	2.316		2.316	2.458		2.458	
VW15	0.100	<u>0.590</u>	<u>0.690</u>	0.065	0.229	0.294	0.077	0.461	<u>0.539</u>	0.032	0.297	0.329	
VW18													
VW19													
VW20	0.032	0.210	0.242	0.039	0.171	0.210	0.084	0.032	0.116	0.032		0.032	
VW20B				0.084	0.077	0.161	0.032	0.119	0.152	0.132		0.132	
VW21													
VW21B													
VW23	0.065	<u>0.855</u>	<u>0.919</u>	0.006	0.284	0.290	0.277	0.132	0.410	0.426	0.197	<u>0.623</u>	
VW24													
VW29	0.113	<u>0.626</u>	<u>0.739</u>	0.100	0.494	<u>0.594</u>	0.361	<u>0.590</u>	<u>0.952</u>	0.361	0.394	<u>0.755</u>	
VW30													
VW31	1.216	0.435	1.652	1.158	0.000	1.158	1.245		1.245	2.026		2.026	
VW32	<u>0.716</u>		<u>0.716</u>	0.394	0.000	0.394	0.494		0.494	<u>0.590</u>	0.132	<u>0.723</u>	
VW35													
VW38													
Period Total (gal)	365.70	128.80	494.50	287.40	64.40	351.80	296.80	43.40	340.20	338.70	31.60	370.30	



Table B-1 PSPH Recovery Summary August 2018 - May 2022 Draft Phase 2 Natural Source Zone Depletion Assessment Report St. Croix Alumina Site

					-			
	Reporting	Period: 5/1/2022-	5/31/2022	Total Recovery for August 2018-May 2022				
Well	Total PSPH Recovered (gpd)	Total Water Recovered (gpd)	Total Fluid Recovered (gpd)	Total PSPH Recovered (gal)	Total Water Recovered (gal)	Total Fluid Recovered (gal)		
VW2	0.132		0.132	53.4	79.6	133.4		
VW4				0.8	14.3	15.1		
VW5	0.145	0.032	0.177	520.3	202.8	723.1		
VW6	2.516		2.516	3255.5	141.8	3397.2		
VW7			0.000	1.6	2.0	3.6		
VW13	<u>0.823</u>		<u>0.823</u>	994.2	365.5	1359.7		
VW13B*	0.290		0.290	2376.2	1502276.8	1504653.0		
VW14	1.677		1.677	3043.8	156.8	3200.6		
VW15	0.165	0.229	0.394	163.9	331.4	495.3		
VW18				16.1	120.2	136.3		
VW19				5.0	25.1	30.1		
VW20	0.165	0.013	0.177	198.8	184.4	383.2		
VW20B	0.065		0.065	225.3	463.0	688.3		
VW21				7.9	48.6	56.6		
VW21B				73.3	259.1	332.4		
VW23	0.065	0.494	<u>0.558</u>	166.4	484.5	650.9		
VW24				127.3	191.8	319.1		
VW29	0.165	0.394	<u>0.558</u>	267.0	623.9	890.8		
VW30				34.7	160.0	194.7		
VW31	1.071		1.071	1541.7	173.6	1715.3		
VW32	0.261	<u>0.887</u>	1.148	599.9	164.0	763.9		
VW35				0.6	24.4	25.1		
VW38				1.0	5.1	6.1		
Period Total (gal)	233.70	63.50	297.20	11104	1461292	1472392		



PSPH Recovery Summary August 2018 - May 2022 Draft Phase 2 Natural Source Zone Depletion Assessment Report St. Croix Alumina Site St. Croix, U.S. Virgin Islands

Notes:

Cells highlighted in gray indicate a pump was not installed.

Cells highlighted in green indicate recovery rate greater than 1 gallon per day.

Cells with underlined values indicate recovery between 0.5 and 1 gallon per day.

*Submersible pump installed.

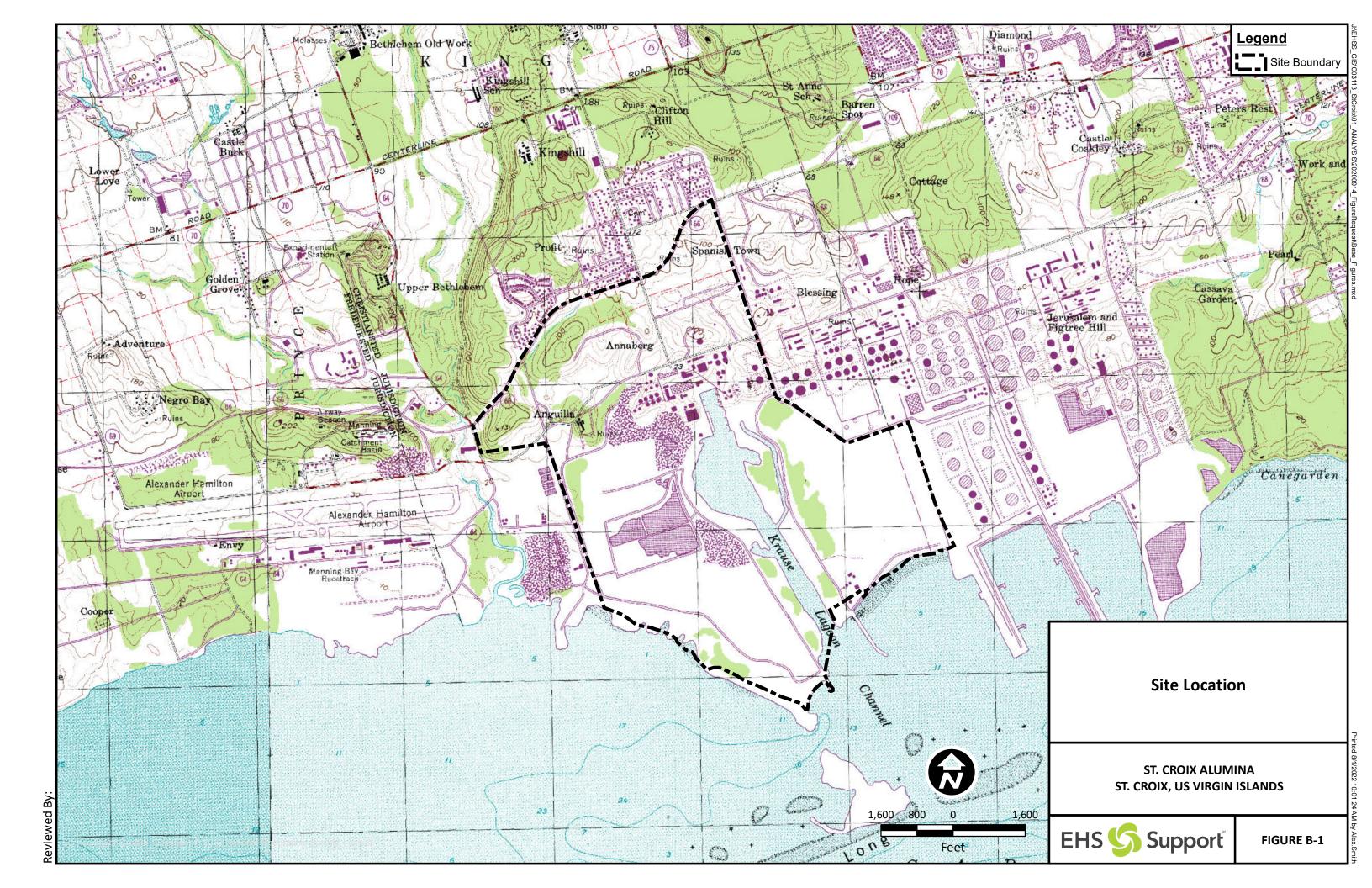
gal = gallons

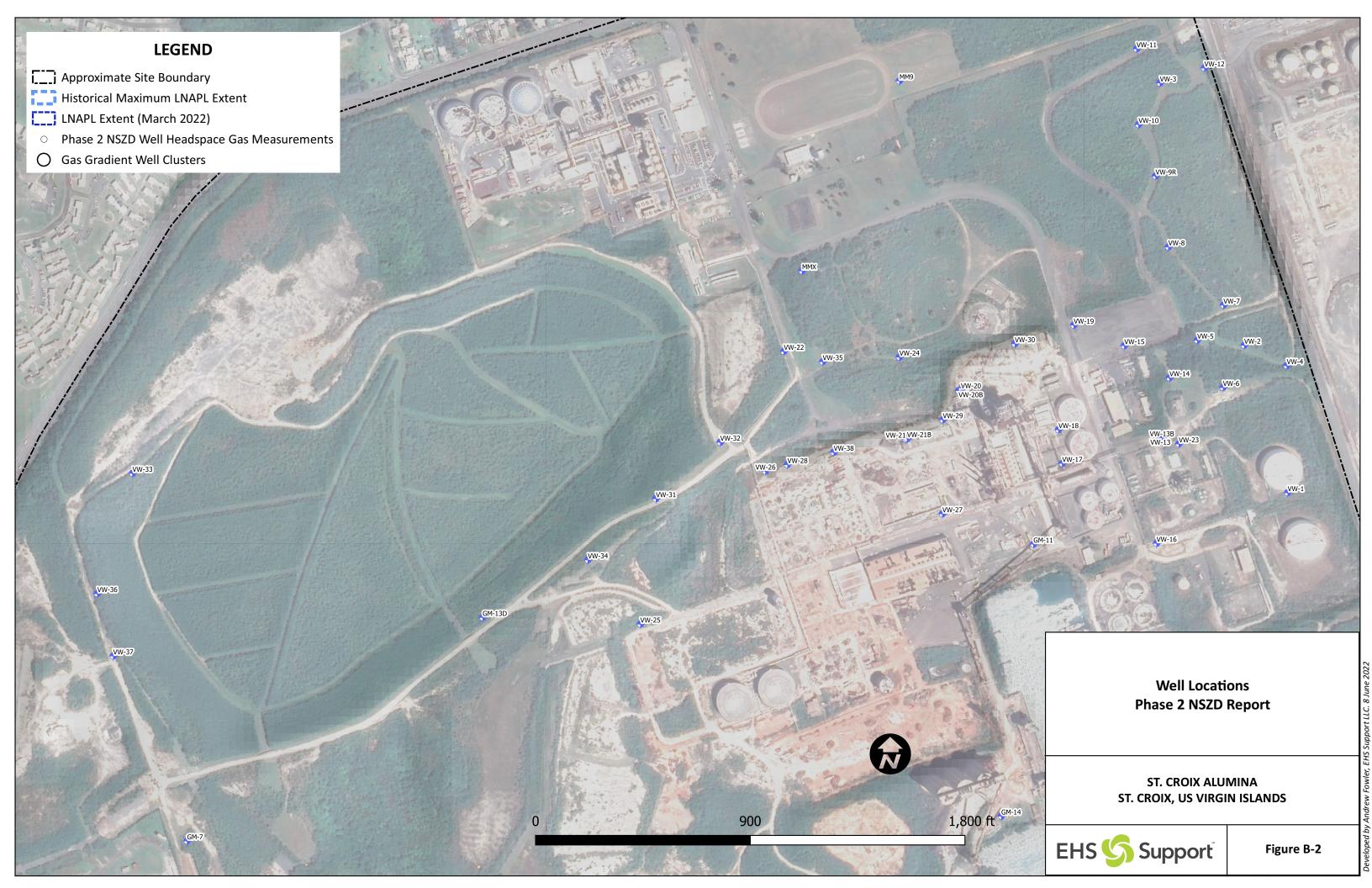
gpd = gallons per day

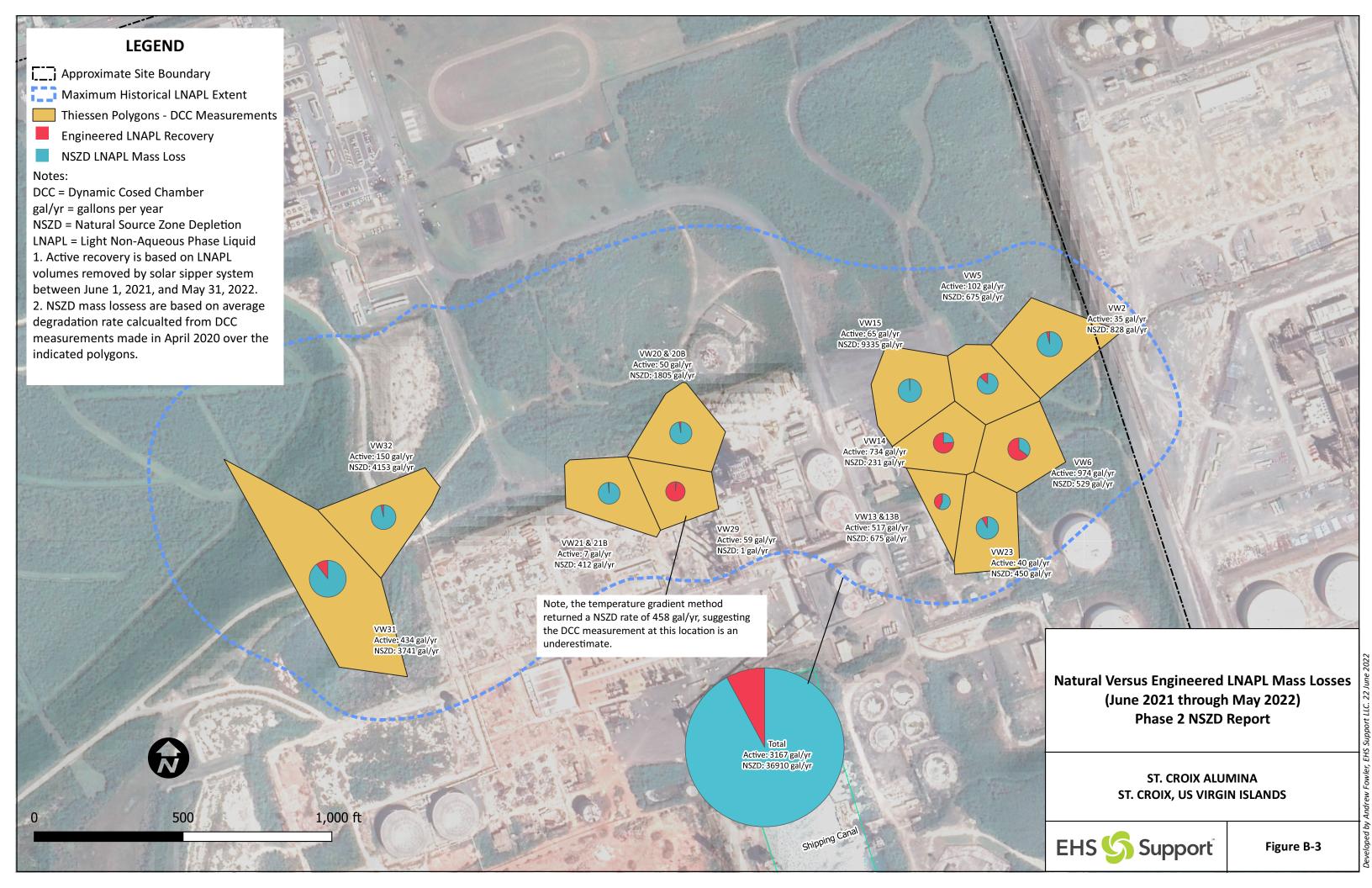
PSPH = phase separated petroleum hydrocarbon



Figures









Attachment A LNAPL Recovery Analysis



MEMO

To: Nigel Goulding

From: Emma Cronin, Jordan Stark

CC: Samuel Parker

Date: July 1, 2022

Re: Reservoir Depletion Analysis Technical Memorandum

Introduction

The following companies entered into an Administrative Order on Consent (AOC), with the United States Environmental Protection Agency (USEPA), Region 2 on May 14, 2001, with an effective date of May 24, 2001:

- St. Croix Alumina, LLC
- ALCOA World Alumina, LLC (formerly known as ALCOA Alumina and Chemical, LLC)
- Virgin Islands Alumina Company
- Century Aluminum Company, Inc.
- Lockheed Martin Corporation
- Hess Oil Virgin Islands Corporation
- HOVENSA LLC

Pursuant to the AOC, these companies have agreed to work together to address phase separated petroleum hydrocarbons (psph) and dissolved phase petroleum hydrocarbon constituents (DPPHC) located beneath the St. Croix Alumina facility in St. Croix, U.S. Virgin Islands ("Site"). Per the AOC, a Project Operating Committee (POC) was formed to design, install, and operate a monitoring and remediation system for the Site.

The July 2020 LNAPL CSM and Remedial Action Work Plan (EHS Support, 2020) provided detailed documentation surrounding a reservoir decline curve analysis using data from the Site monitoring well network from 2002 to May 2020. A revision to the analysis was prepared to include data from ongoing monitoring of the well extraction network that occurred from May 2020 through July 31, 2021, and was provided in the Phase 1 NSZD Report (EHS Support, 2021).

The purpose of this technical memorandum is to update the reservoir depletion curve analysis with recovery data for the Site collected from July 2021 through May 2022. This information is used to determine whether extraction wells are suitable for removal from the monitoring program based on the recovery of PSPH as presented in Figure 6-3 of the 2020 LNAPL CSM and Remedial Action Work Plan (EHS Support, 2020).

Nigel Goulding Reservoir Depletion Analysis Technical Memorandum July 1, 2022



Recovery data are presented in the context of the decision logic diagram for the continued operation of LNAPL recovery wells (Figure 6-3 from LNAPL CSM and Remedial Action Plan [EHS Support, 2020], replicated below), which identifies the following key metrics:

- Observation of declining recovery rates
- Recovery of 90 percent of the potentially recoverable light non-aqueous phase liquid (LNAPL)
 volume as determined by recovery decline curve analysis
- LNAPL recovery rates of less than 1 gallon per day (gpd)
- LNAPL transmissivities of less than 0.8 square feet (ft²)/day

Memo Objectives

The objectives of this memo are as follows:

- Update the cumulative PSPH recovery rate database to include monitoring and extraction data from July 2021 to May 2022.
- Analyze the reservoir depletion using ordinary least squares (OLS) and Theil-Sen regression approaches to estimate the theoretical maximum recovery volume in each well.
- Determine which monitoring wells meet the criteria for 90 percent of theoretical maximum PSPH recovery volume.
- Estimate when the 90 percent theoretical maximum recovery volume threshold will be met for wells that do not meet the above criteria.
- Identify wells where LNAPL recovery is below 1 gpd.

Data Analysis

This section describes the updates to the recovery rate dataset, summarizes the statistical analyses conducted, and outlines the approach used to determine which monitoring wells met the criteria.

The reservoir depletion curve analysis was conducted using available extraction rate and recovery data from 20 wells. PSPH recovery rates and cumulative PSPH recovery volumes from July 2021 to May 2022 were collated into the existing database of recovery well data. Wells VW26 and VW28 were not included in these analyses as they had never exceeded 1 gpd PSPH and were not included in the July 2021 datafile.

OLS and Theil-Sen trend methods were used to evaluate recovery trends in the 20 wells. Model fitting was completed using the R program (www.R-project.org) on untransformed PSPH recovery rate and PSPH cumulative recovery data. The statistical "Kendall" and "mblm" packages were used to calculate the slope and intercept model parameters. The Theil-Sen regression approach pairs individual measurements of the PSPH recovery rate and cumulative PSPH recovery volume and calculates a slope between them. The median of the pairwise comparisons is calculated to obtain a central tendency of the slope. A Mann-Kendall Test was used to determine whether the slope of a Theil-Sen trendline is significantly decreasing. Once the slope was calculated, the intercept was calculated as the median

¹ A statistical modeling package available for R software.

² Median-based linear models



intercept for *y=mx+b* (where y is the value on the vertical axis, m is the slope, x is the value on the horizontal axis, and b is the vertical axis intercept). This approach is more robust than traditional OLS approaches and less sensitive to outliers or inconsistent sampling periods than an OLS regression. Scatterplots illustrating the relationship between the recovery rate and cumulative recovery volume were generated. These figures were created using tri-panel plots with the first panel maintaining a fixed axis for the recovery rate to enable a comparison between the wells. The next two panels were used to highlight both the OLS and Theil-Sen analyses results (**Attachment A**).

Regression analyses were performed using both the OLS and Theil-Sen methods, and the resulting parameter estimates from the two models were compared. Parameter estimates were similar for model fitting procedures (**Attachment A**). However, the Theil-Sen and Mann-Kendall approach was selected for subsequent consideration because the statistical approach is less sensitive to skewed or heteroskedastic data when evaluating trends (USEPA, 2009). Application of the regression analyses used parameter estimates based on the Theil-Sen approach.

Intercepts and slopes calculated from Theil-Sen regressions for each well were used to calculate the cumulative PSPH volume recovered when the rate of recovery volume is equal to zero ("zero-point") for each well. The cumulative recovery volume at this zero-point is the theoretical maximum recovery volume for each well. Theoretical maxima were then compared to the measured cumulative PSPH recovered through July 2021 to determine if wells had already exceeded 90 percent of the theoretical recoverable PSPH.

For wells that have not already exceeded 90 percent of theoretical recoverable PSPH, estimates were made for when that threshold will be achieved. To estimate the date on which a well will have 90 percent recovery, the cumulative PSPH (y-axis) was plotted over cumulative days pumped (x-axis) and a linear regression was fit. The linear regression equations were used to estimate the month during which the well would exceed the 90 percent theoretical recoverable PSPH threshold based on the time passed since the start of records included in the analysis.

Theil- Sen Regression Findings

Results of the Theil-Sen regression analysis are provided in **Table 1**. Wells VW6, VW13, VW14, VW20, VW20B, VW21, VW24, and VW29 had significantly decreasing trends based on the Mann-Kendall test. Although extraction wells VW13B, VW21B, VW30, and VW38 had negative Theil-Sen slopes, the Mann-Kendall test did not exhibit significantly decreasing trends. Seven of the wells (VW6, VW13, VW14, VW20, VW20B, VW21, and VW38) exhibited recovery exceeding 90 percent of the theoretical maxima.

Table 1 Theil-Sen Regression Parameters and Theoretical Maximum Recoverable PSPH by Extraction Well

Well	Theil-Sen Intercept (thousands of gallons)	Theil-Sen Slope	Cumulative PSPH Recovered to May 2022 (thousands of gallons)	Theoretical Maximum (thousands of gallons)	% of Theoretical Maximum Recovered	Mann- Kendall p-value
VW13	23.70	-0.28	84.182	85.771	98.15	<0.01



Well	Theil-Sen Intercept (thousands of gallons)	Theil-Sen Slope	Cumulative PSPH Recovered to May 2022 (thousands of gallons)	Theoretical Maximum (thousands of gallons)	% of Theoretical Maximum Recovered	Mann- Kendall p-value
VW13B	3.63	-0.11	20.387	32.519	62.69	0.16
VW14	35.17	-0.26	128.107	133.535	95.94	<0.01
VW15	0.05	0.94	0.105	-0.055	-189.66	0.18
VW18	0.02	0.00	0.027			0.96
VW19	0.01	18.02	0.005	0	-1625.25	0.09
VW2	0.03	2.94	0.054	-0.012	-458.71	0.15
VW20	10.89	-0.21	52.163	52.729	98.93	<0.01
VW20B	55.54	-0.91	61.151	61.223	99.88	<0.01
VW21	6.36	-0.22	26.881	28.645	93.84	<0.01
VW21B	0.24	-0.03	6.370	8.513	74.83	0.11
VW23	0.04	0.29	0.133	-0.147	-90.77	0.16
VW24	0.40	-2.76	0.127	0.144	88.47	0.01
VW29	0.43	-0.37	0.892	1.161	76.82	0.02
VW30	0.12	-0.31	0.196	0.391	50.24	0.29
VW31	0.37	0.92	1.193	-0.402	-297.00	<0.01
VW32	0.10	0.95	0.461	-0.110	-417.81	<0.01
VW38	1.90	-0.29	6.285	6.598	95.26	0.06
VW5	0.18	0.39	0.411	-0.461	-89.18	0.12
VW6	35.56	-0.38	88.564	92.571	95.67	<0.01

^{-- =} insufficient data or calculation

PSPH = phase separated petroleum hydrocarbons

Summary of Key Decision Logic Criteria

Results of the regression analysis and recovery data were compared to key decision logic criteria to identify the status of recovery wells in terms of shutdown criteria. The comparison is provided in **Table 2**.

Table 2 Summary of Key Decision Logic Criteria

Well	Thiel-Sen Slope Declining?	90% of theoretical maximum recovered?	Rate <1 gpd for at least the past year?	Data Scatter indicates low transmissivity?	Data collected from August 2021 to May 2022 period?
VW2			Yes	Yes	Yes
VW5			Yes	Yes	Yes
VW6	Yes	Yes			Yes
VW13	Yes	Yes			Yes
VW13B	Yes*				Yes



Well	Thiel-Sen Slope Declining?	90% of theoretical maximum recovered?	Rate <1 gpd for at least the past year?	Data Scatter indicates low transmissivity?	Data collected from August 2021 to May 2022 period?
VW14	Yes	Yes			Yes
VW15			Yes	Yes	Yes
VW18			Yes	Yes	
VW19			Yes		
VW20	Yes	Yes	Yes		Yes
VW20B	Yes	Yes	Yes		Yes
VW21	Yes*	Yes	Yes		
VW21B	Yes		Yes		Yes
VW23			Yes	Yes	Yes
VW24	Yes	Nearly Yes (88.5 %)	Yes	Yes	
VW29	Yes		Yes	Yes	Yes
VW30	Yes*		Yes	Yes	
VW31					Yes
VW32			Yes		Yes
VW38	Yes*	Yes	Yes		

^{*} Indicates that the negative Thiel-Sen slope is not significantly different from zero (p>0.05). gpd = gallons per day

Estimated 90 Percent Recovery Date Findings

Estimated dates for 90 percent of the theoretical maximum recovery volumes are provided in **Table 3**. These calculations represent wells that have negative Theil-Sen slopes but have not already achieved 90 percent of the theoretical recovery volume.

Table 3 Estimated Dates for 90% of Theoretical Maximum Volume Recovery

Well	90% Theoretical Recovery Volume (Gallons)	Estimated Date of 90% Recovery
VW13B	29,267	September 2029
VW21B	7,661	September 2022
VW24 *	129	January 2020
VW29	1,045	March 2024
VW30	352	December 2026

^{*} Recovery has not been measured at VW24 since February of 2020, thus the predicted 90% recovery rate is indicated as a date in the past.

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Conclusions

Wells VW6, VW13, VW14, VW20, VW20B, VW21, and VW38 exhibited recovery which exceeded 90 percent of the theoretical maxima, and VW24 likely achieved the 90 percent threshold since the recovery was last measured. Wells VW13B, VW21B, VW29, and VW30 have trend lines that show achievement of the 90 percent recovery thresholds predicted in the near future.

Wells VW2, VW5, VW15, VW18, VW23, VW24, VW29, and VW30 have consistently yielded recovery rates less than 1 gpd, with the majority of recovery records below 0.25 gpd. These wells exhibit variable recovery rates due to the low inherent LNAPL transmissivity in the formation with this natural variability limiting the utility of the reservoir decline curve technique. Inherently within wells that have low LNAPL transmissivity/recovery, the volumes of LNAPL that can be recovered are small, and natural source zone depletion (NSZD) rates will exceed recovery rates.

Recovery wells VW6, VW13, VW13B, and VW14 continue to recover greater than 1 gpd, with the remainder of wells recovering limited volumes. Limited benefits will be realized from the continued operation of these low-recovery volume wells. Skimming operations could be terminated in these wells with limited effect on total recovery volumes. Of the wells still recovering 1 gpd, wells VW6, VW13, and VW14 have achieved the goal of removing 90 percent of the recoverable volume; therefore, termination of recovery in these wells could be considered in the near future.

References

EHS Support. (2020). LNAPL CSM and Remedial Action Work Plan. St. Croix, U.S. Virgin Islands. July.

EHS Support. (2021). Phase 1 Natural Source Zone Depletion Assessment Report. St. Croix Alumina Site, St. Croix, U. S. Virgin Islands. December.

USEPA. (2009). Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance (EPA 350-R-09-007). April.

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Attachment A PSPH Recovery Rate and Cumulative Recovery Volume Plots

